GENERAL SERVICES ADMINISTRATION
CONTRACT NUMBER GS-10F-0076K
DELIVERY ORDER NUMBER N62474-03-F-4023

Sampling and Analysis Plan (Field Sampling/Quality Assurance Project Plan)

Data Gaps Evaluation for the Litigation Area

Naval Weapons Station Seal Beach Detachment, Concord
Concord, California

GSA.105.00003

DRAFT

March 28, 2003

Engineering Field Activity West
Naval Facilities Engineering Command
San Bruno, California

TETRA TECH, INC.

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Draft
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DATA GAPS EVALUATION
LITIGATION AREA

Naval Weapons Station Seal Beach Detachment Concord
Concord, California

March 28, 2003

Prepared for

DEPARTMENT OF THE NAVY
Engineering Field Activity West
Daly City, California

Prepared by

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SAMPLING AND ANALYSIS PLAN
(FIELD SAMPLING PLAN/QUALITY ASSURANCE PROJECT PLAN)
DATA GAPS EVALUATION
LITIGATION AREA
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD
CONCORD, CALIFORNIA

Prepared for:

DEPARTMENT OF THE NAVY

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TABLE 1

EPA QA/R-5 QAPP ELEMENTS
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

U.S. EPA QA/R-5 QAPP ELEMENT	TtEMI SAMPLING AND ANALYSIS PLAN (SAP)
A1 Title and Approval Sheet	Title and Approval Sheet
A2 Table of Contents	Table of Contents
A3 Distribution List	Distribution List
A4 Project/Task Organization	1.4 Project Organization
A5 Problem Definition/Background	1.1 Problem Definition and Background
A6 Project/Task Description	1.2 Project Description
A7 Quality Objectives and Criteria	1.3 Quality Objectives and Criteria
A8 Special Training/Certification	1.5 Special Training and Certification
A9 Documents and Records	1.6 Documents and Records
B1 Sampling Process Design	2.1 Sampling Process Design
B2 Sampling Methods	2.2 Sampling Methods
B3 Sample Handling and Custody	2.3 Sample Handling and Custody
B4 Analytical Methods	2.4 Analytical Methods
B5 Quality Control	2.5 Quality Control
B6 Instrument/Equipment Testing, Inspection, and Maintenance	2.6 Equipment Testing, Inspection, and Maintenance
B7 Instrument/Equipment Calibration and Frequency	2.7 Instrument Calibration and Frequency
B8 Inspection/Acceptance of Supplies and Consumables	2.8 Inspection and Acceptance of Supplies and Consumables
B9 Non-direct Measurements	2.9 Non-Direct Measurements
B10 Data Management	2.10 Data Management
C1 Assessment and Response Actions	3.1 Assessment and Response Actions
C2 Reports to Management	3.2 Reports to Management
D1 Data Review, Verification, and Validation	4.1 Data Review, Verification, and Validation
D2 Validation and Verification Methods	
D3 Reconciliation with User Requirements	4.2 Reconciliation with User Requirements

Notes:

SAP Sampling and Analysis Plan
TtEMI Tetra Tech EM Inc.
U.S. EPA U.S. Environmental Protection Agency

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CONTENTS (Continued)

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
BERA	Baseline Ecological Risk Assessment
bgs	Below ground surface
°C	Degrees Celsius
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract laboratory program
COC	Chain-of-custody
CPC	Chemical Pigment Company
CPR	Cardiopulmonary resuscitation
DHS	Department of Health Services
DO	Delivery Order
DOT	Department of Transportation
DQA	Data quality assessment
DQO	Data quality objective
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
EDD	Electronic data deliverable
EFA	Engineering Field Activity
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ER-L	Effects range-low
FS	Feasibility study
FSP	Field sampling plan
FTL	Field team leader
GCC	General Chemical Company
GPS	Global Positioning System
GSA	General Services Administration
HAR	Hydrogeologic Assessment Report
HHRA	Human health risk assessment
HSA	Hollow stem auger
HSP	Health and safety plan

ACRONYMS AND ABBREVIATIONS (Continued)

ID	Identification
IDL	Instrument detection limit
IDW	Investigation-derived waste
IR	Installation restoration
IRCDQM	Installation Restoration Chemical Data Quality Manual
IRP	Installation restoration program
L	Liter
L/min	Liter per minute
LCS	Laboratory control spike
LIMS	Laboratory information management system
MCAWW	Methods for Chemical Analysis of Water and Waste
MDL	Method detection limit
µg/kg	Microgram per kilogram
mg/kg	Milligram per kilogram
ml/min	Milliliter per minute
MQO	Measurement quality objective
MS	Matrix spike
MSD	Matrix spike duplicate
msl	mean sea level
MSR	Monthly Status Report
NEDD	Navy Electronic Data Deliverable
NEDTS	Navy Environmental Data Transfer Standards
NFESC	Naval Facilities Engineering Service Center
NOAA	National Oceanic and Atmospheric Administration
NWS SBD	Naval Weapons Station Seal Beach Detachment
OHSC	On-site health and safety coordinator
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PARCC	Precision, accuracy, representativeness, completeness, and comparability
PCB	Polychlorinated biphenyl
PE	Performance evaluation
PPE	Personal protective equipment
PRG	Preliminary remediation goal
PRRL	Project-required reporting limit
PVC	Polyvinyl chloride

ACRONYMS AND ABBREVIATIONS (Continued)

QA	Quality assurance
QA/QC	Quality assurance and quality control
QAPP	Quality assurance project plan
QC	Quality control
QEA	Qualitative Ecological Assessment
RAP	Remedial Action Plan
RASS	Remedial Action Sub-site
RI	Remedial Investigation
ROD	Record of Decision
RPD	Relative percent difference
RPM	Remedial project manager
SAMTRAK	TtEMI's sample tracking database
SAP	Sampling and analysis plan
SDG	Sample delivery group
SOP	Standard operating procedure
SOW	Statement of work
SPTC	Southern Pacific Transportation Company
SQL	Sample quantitation limit
SVOC	Semivolatile organic compound
SWDIV	Naval Facilities Engineering Command Southwest Division
TDS	Total dissolved solids
TER	Technical Evaluation Report
TOC	Total organic carbon
TSA	Technical systems audit
TSS	Total suspended solids
TtEMI	Tetra Tech EM Inc.
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
VOC	Volatile organic compound

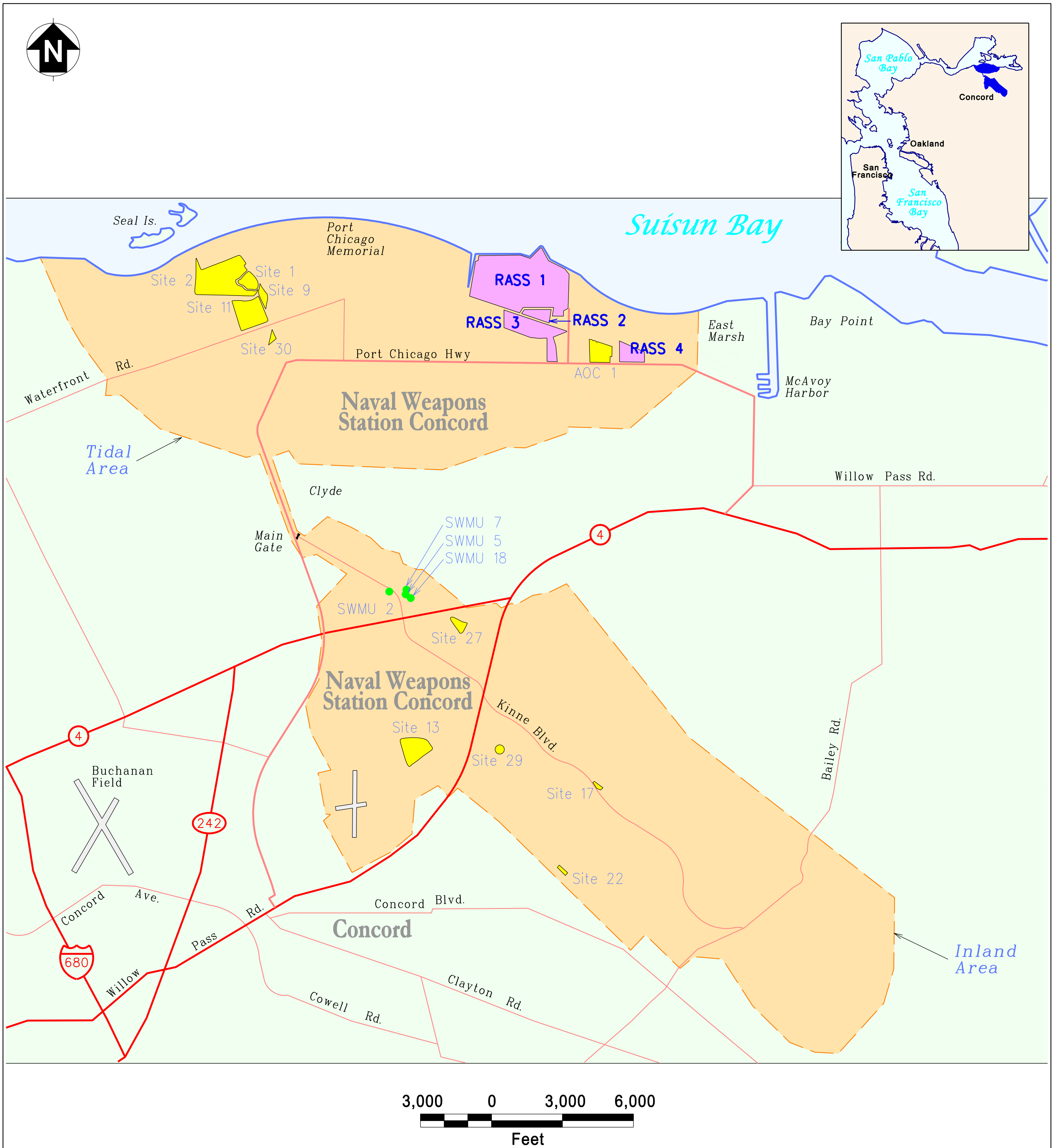
1.0 PROJECT DESCRIPTION AND MANAGEMENT

Tetra Tech EM Inc. (TtEMI) received Delivery Order (DO) ID No. N62474-03-F-4023 under the General Services Administration (GSA) Contract No. GS-10F-0076K. This DO is in support of the Naval Facilities Engineering Command, Engineering Field Activity (EFA) West, who are responsible for conducting the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) response action under the Department of Navy's Installation Restoration Program (IRP) at the Naval Weapons Station Seal Beach Detachment (NWS SBD) Concord, California. The DO requires TtEMI to conduct a field investigation at the remedial action sub-sites (RASS) located in the Tidal Area section of NWS SBD Concord. The RASSs are located in a portion of the NWS SBD Concord Tidal Area known as the Litigation Area (Figure 1).

TtEMI prepared this Sampling and Analysis Plan (SAP), consisting of a Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) in an integrated format, to support the proposed field investigation at the Litigation Area. The purpose of the field investigation is to obtain additional information needed to evaluate data gaps identified in the Draft Final Five-Year Periodic Review Assessment report (TtEMI 2002a). Data from the investigation will assist the Navy in evaluating potential off-site sources of contamination and evaluating future response action(s) to be considered in meeting the applicable or relevant and appropriate requirements (ARAR) for the RASSs. The investigation results will be presented in a technical evaluation report (TER).

Table 1 follows the approval page at the beginning of this SAP. The table provides information on how this SAP addresses all QAPP elements currently required by the U.S. Environmental Protection Agency (EPA) QA/R-5 guidance document (EPA 2001).

In this document, tables and figures follow the first reference in the text. Appendix A contains Method, Precision and Accuracy Goals, Appendix B contains Standard Operating Procedures, Appendix C contains all Field Forms, Appendix D lists Project-Required Reporting Limits, and Appendix E lists Navy-approved laboratories for sample analysis.



Litigation Area Sites

Remedial Investigation Sites

Solid Waste Management Unit (SWMU)

Note:
RASS - Remedial Action Subsite

Tetra Tech EM Inc.

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Concord, California
Engineering Field Activity West, Daly City

FIGURE 1
LITIGATION AREA
SITE LOCATION MAP

1.1 PROBLEM DEFINITION AND BACKGROUND

This section describes the following:

- Purpose of the Investigation (Section 1.1.1)
- Problem to be Solved (Section 1.1.2)
- Facility Background (Section 1.1.3)
- Site Description (Section 1.1.4)
- Physical Setting (Section 1.1.5)
- Summary of Previous Investigations (Section 1.1.6)
- Principal Decision Makers (Section 1.1.7)
- Technical or Regulatory Standards (Section 1.1.8)

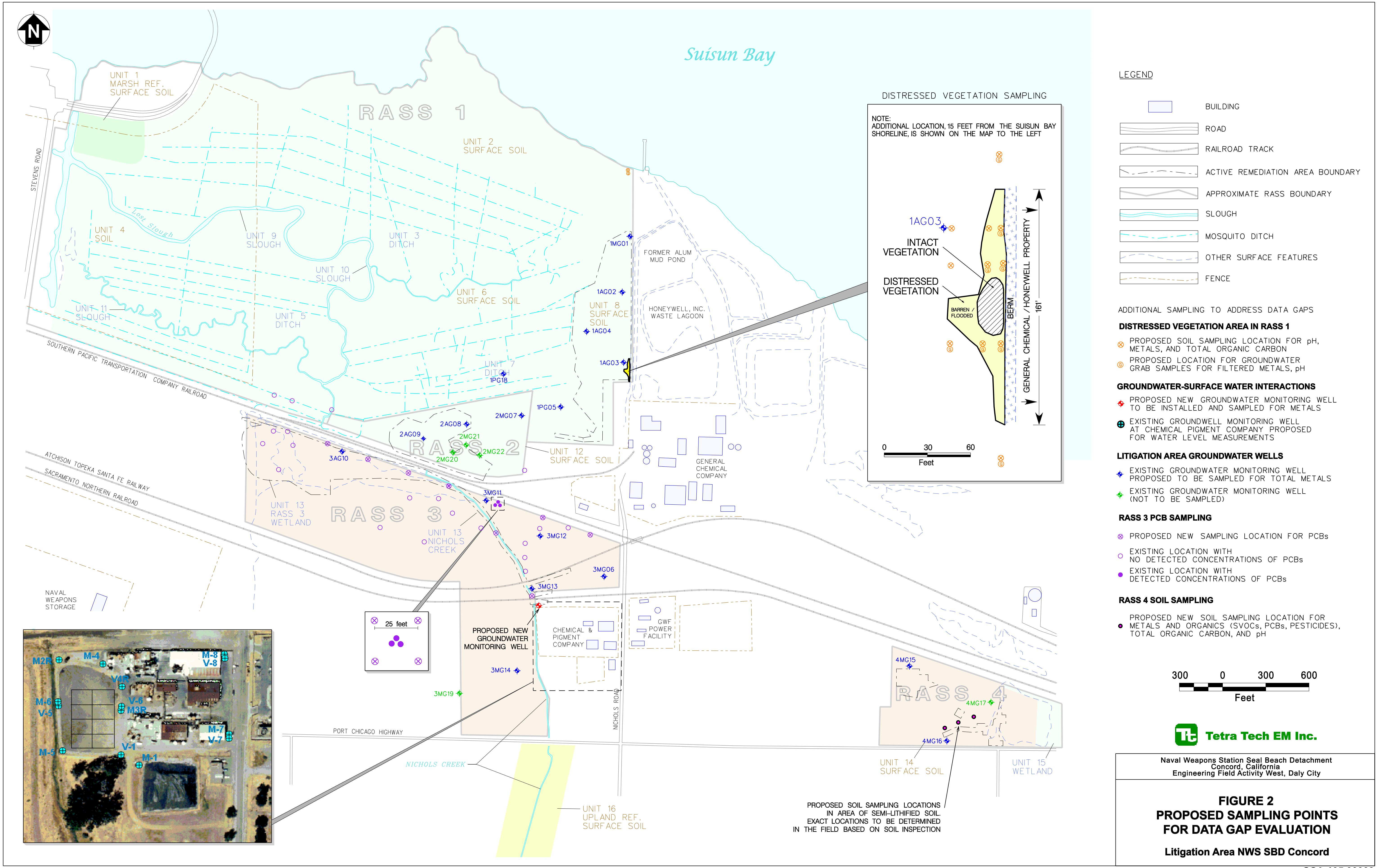
1.1.1 Purpose of the Investigation

The purpose of the field investigation at the Litigation Area is to obtain additional information needed to evaluate data gaps identified in the Draft Final Five-Year Review Report (TtEMI 2002a). The Navy is concerned that the adjoining chemical companies and railroad properties may be ongoing sources of contamination to RASSs 1 and 3. This investigation will be conducted to further evaluate potential off-site sources and to resolve any on-site data gaps before addressing concerns about the protectiveness of the present remedy within the Litigation Area.

To achieve these goals, soil and groundwater samples will be collected, and hydrogeologic data will be obtained to characterize specific areas in RASSs 1 and 3 bordering potentially contaminated off-site sources. An area of concern in RASS 4 consisting of semi-lithified or ashy soil will also be sampled to evaluate the chemical composition of unusual soils observed at the site. Further, groundwater wells throughout the Litigation Area will be sampled to determine whether flow conditions or groundwater quality have changed since the last groundwater sampling event in October 1996. The results of this field investigation will be discussed in the TER.

1.1.2 Problem To Be Solved

Data gaps identified during the five-year review process for the Litigation Area or during risk management meetings need to be addressed through focused site investigation and evaluation. The data gaps and the plans to evaluate them are described in the following sections. Figure 2 identifies data gaps investigation areas and proposed sampling locations.



Suisun Bay
RASS 1
RASS 2
RASS 3
RASS 4
UNIT 1 MARSH REF. SURFACE SOIL
UNIT 2 SURFACE SOIL
UNIT 3 DITCH
UNIT 4 SOIL
UNIT 5 DITCH
UNIT 6 SURFACE SOIL
UNIT 7 DITCH
UNIT 8 SURFACE SOIL
UNIT 9 SLOUGH
UNIT 10 SLOUGH
UNIT 11 SLOUGH
UNIT 12 SURFACE SOIL
UNIT 13 RASS 3 WETLAND
UNIT 13 NICHOLS CREEK
UNIT 14 SURFACE SOIL
UNIT 15 WETLAND
UNIT 16 UPLAND REF. SURFACE SOIL
Lost Slough
NICHOLS CREEK
STEVENS ROAD
NICHOLS ROAD
PORT CHICAGO HIGHWAY
SOUTHERN PACIFIC TRANSPORTATION COMPANY RAILROAD
ATCHISON TOPEKA SANTA FE RAILWAY
SACRAMENTO NORTHERN RAILROAD
NAVAL WEAPONS STORAGE
FORMER ALUM MUD POND
HONEYWELL, INC. WASTE LAGOON
GENERAL CHEMICAL COMPANY
CHEMICAL & PIGMENT COMPANY
GWF POWER FACILITY
1MG01
1AG02
1AG04
1AG03
1PG18
1PG05
2MG07
2AG08
2AG09
2MG21
2MG22
2MG20
3AG10
3MG11
3MG12
3MG06
3MG13
3MG14
3MG19
4MG15
4MG17
4MG16
25 feet
PROPOSED NEW GROUNDWATER MONITORING WELL
PROPOSED SOIL SAMPLING LOCATIONS IN AREA OF SEMI-LITHIFIED SOIL. EXACT LOCATIONS TO BE DETERMINED IN THE FIELD BASED ON SOIL INSPECTION
M-2R
M-4
M-8
V-8
V-4R
M-6
V-5
V-6
M3R
M-7
V-7
M-5
V-1
M-1
DISTRESSED VEGETATION SAMPLING
NOTE: ADDITIONAL LOCATION, 15 FEET FROM THE SUISUN BAY SHORELINE, IS SHOWN ON THE MAP TO THE LEFT
1AG03
INTACT VEGETATION
DISTRESSED VEGETATION
BARREN / FLOODED
BERM
GENERAL CHEMICAL / HONEYWELL PROPERTY
161'
0 30 60
Feet
LEGEND
BUILDING
ROAD
RAILROAD TRACK
ACTIVE REMEDIATION AREA BOUNDARY
APPROXIMATE RASS BOUNDARY
SLOUGH
MOSQUITO DITCH
OTHER SURFACE FEATURES
FENCE
ADDITIONAL SAMPLING TO ADDRESS DATA GAPS
DISTRESSED VEGETATION AREA IN RASS 1
PROPOSED SOIL SAMPLING LOCATION FOR pH, METALS, AND TOTAL ORGANIC CARBON
PROPOSED LOCATION FOR GROUNDWATER GRAB SAMPLES FOR FILTERED METALS, pH
GROUNDWATER-SURFACE WATER INTERACTIONS
PROPOSED NEW GROUNDWATER MONITORING WELL TO BE INSTALLED AND SAMPLED FOR METALS
EXISTING GROUNDWELL MONITORING WELL AT CHEMICAL PIGMENT COMPANY PROPOSED FOR WATER LEVEL MEASUREMENTS
LITIGATION AREA GROUNDWATER WELLS
EXISTING GROUNDWATER MONITORING WELL PROPOSED TO BE SAMPLED FOR TOTAL METALS
EXISTING GROUNDWATER MONITORING WELL (NOT TO BE SAMPLED)
RASS 3 PCB SAMPLING
PROPOSED NEW SAMPLING LOCATION FOR PCBs
EXISTING LOCATION WITH NO DETECTED CONCENTRATIONS OF PCBs
EXISTING LOCATION WITH DETECTED CONCENTRATIONS OF PCBs
RASS 4 SOIL SAMPLING
PROPOSED NEW SOIL SAMPLING LOCATION FOR METALS AND ORGANICS (SVOCs, PCBs, PESTICIDES), TOTAL ORGANIC CARBON, AND pH
300 0 300 600
Feet
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Naval Weapons Station Seal Beach Detachment
Concord, California
Engineering Field Activity West, Daly City
FIGURE 2
PROPOSED SAMPLING POINTS FOR DATA GAP EVALUATION
Litigation Area NWS SBD Concord

1.1.2.1 Distressed Vegetation Area in RASS 1

An area of distressed vegetation was observed in the remediated area of RASS 1 along the berm separating the General Chemical Company (GCC) facility and the Honeywell, Inc. alum waste ponds from the Navy's property (Figure 2). The area of distressed vegetation was first observed in July 2001 during the site inspection tour, and was still evident in November 2002. A file review of documents at the California Environmental Protection Agency-Department of Toxic Substances Control (DTSC), conducted during the five-year review, indicated high groundwater and soil concentrations of metals and low pH at the GCC facility, and groundwater flows westward toward the Litigation Area (TtEMI 2002a, Appendix E). A focused investigation is required to determine whether the area of distressed vegetation is the result of chemical migration from GCC or Honeywell, Inc. facilities into remediated marsh soils on Navy property.

The investigation will extend beyond the area of distressed vegetation to allow comparison with areas with normal (healthy) vegetation and to provide at least one sample on the margin of Suisun Bay (Figure 2). The Navy will sample soil and grab groundwater samples to evaluate the likely pathways of contaminant migration from neighboring sources. The project objectives and measurements for the sampling in the distressed vegetation area are described in Sections 1.2.1 and 1.2.2.

1.1.2.2 Groundwater-Surface Water Interactions at Chemical and Pigment Company Border

Based on a file review at DTSC, the Navy is concerned about historic data that show high concentrations of zinc and other metals in groundwater samples collected from wells in the center and the northwestern corner of Chemical and Pigment Company (CPC) in 1998 (Cooper, White, and Cooper 1999). This contamination may be flowing toward Navy property and surfacing into Nichols Creek (Figure 2). Groundwater in this area flows north or west based on data from wells located on NWS SBD Concord property. Groundwater flows to the west in the perched zone and to the northeast in the deeper sand body based on reports submitted for CPC (Environmental Solutions 1987). The extent of groundwater-surface water interaction in Nichols Creek near the CPC border is unknown. The Navy plans to install one new groundwater monitoring well and conduct a focused groundwater investigation on Navy property bordering the northwestern corner of CPC property along Nichols Creek and adjacent areas in RASS 3 to evaluate the groundwater-surface water interaction in this area and the likelihood that groundwater at CPC is adversely affecting Nichols Creek or the Navy's property. The Navy will also request access to the CPC facility to conduct water level measurements in groundwater wells at CPC. The objectives and measurements for this investigation are provided in Sections 1.2.1 and 1.2.2, respectively.

1.1.2.3 Litigation Area Groundwater Well Sampling

The Navy most recently sampled groundwater wells (11 of 22 existing wells) in the Litigation Area in October 1996. As a result, the Navy will sample a subset of groundwater wells to determine whether flow conditions or groundwater quality have changed since the October 1996 sampling event. Specific objectives and measurements for this current groundwater well sampling are described in Sections 1.2.1 and 1.2.2, respectively.

1.1.2.4 RASS 3 Polychlorinated Biphenyl Sampling

The Baseline Ecological Risk Assessment (BERA) conducted as part of the five-year review concluded that polychlorinated biphenyls (PCB) did not pose unacceptable risk to ecological receptors (TtEMI 2002a). However, the BERA did acknowledge that insufficient information existed for areas within RASS 3 along the Southern Pacific Transportation Company (SPTC) railroad track property to adequately characterize PCB concentrations for this portion of the site (Figure 2). In 1996, total PCBs were detected at a concentration of 480 micrograms per kilogram (μg/kg) at a single location in RASS 3 along the SPTC railway tracks. In addition, total PCBs were detected at concentrations ranging from 70 to 1,500 μg/kg in three confirmation samples collected within a few meters of the original location.

The Navy will conduct additional PCB analysis of soil samples collected from the northern portion of RASS 3 along the railroad track property and near the highest detected PCB concentrations to fully characterize the site. Based on discussions with the regulatory and trustee agencies, the Navy will also collect samples in the nearby Nichols Creek drainage area to assess potential upstream sources. Specific objectives and measurements for this sampling are described in Sections 1.2.1 and 1.2.2, respectively.

1.1.2.5 RASS 4 Semi-lithified Soil Sampling

During the site inspection tour in July 2002, the group noticed a semi-lithified or ashy soil near the RASS 4 remediated area in some motorcycle tracks left by trespassers (Figure 2). The unusual nature of the soil raised questions about its source and chemical composition. The Navy reviewed historic aerial photographs from 1957 to 1986 to determine whether previous sampling efforts (pre- and postremediation) were conducted in the area of semi-lithified soil and in other areas at the site that had a history of waste disposal. Based on this review, it was determined that the Navy had adequately sampled the portions of the site where historical activities might have resulted in the release of hazardous waste; however, it was not possible to determine whether previous samples of the semi-lithified soil were collected. Consequently, the Navy plans to collect a few samples of the semi-lithified soil for chemical analysis to characterize these unusual soils. Specific objectives and measurements for this sampling are described in Sections 1.2.1 and 1.2.2, respectively.

1.1.3 Facility Background

NWS SBD Concord is in north-central Contra Costa County, approximately 30 miles northeast of San Francisco, California (Figure 1). The Navy facility operates an ocean-shipping terminal to transfer ordnance from trucks or railcars to ships and from ships to land transportation vehicles. The facility is bounded on the north by Suisun Bay, on the south and west by the city of Concord (population 116,000), and on the east by private land and the city of Pittsburg. It encompasses almost 13,000 acres in three holdings: the Inland Area, the Tidal Area, and a radiography facility at Pittsburg.

In the late 1960s and the early 1970s, the Navy purchased several parcels of land to create a buffer zone around the Tidal Area. Eight of those parcels, which cover a total of approximately 307 acres, were subsequently found to be contaminated with metals resulting primarily from waste disposal activities and historic spills from off-site neighboring chemical companies; some smaller on-site historic (non-Navy) sources were also located in several parcels. The Navy did not conduct any activities in these parcels that contributed contamination. Because the Navy has been involved in extensive litigation with owners of adjacent properties to recover remediation costs for these contaminated sites, the parcels are now referred to as the Litigation Area.

The U.S. Army Corps of Engineers (USACE) completed a Remedial Investigation (RI) (Lee and others 1986, 1988) and an Feasibility Study (FS) (Cullinane and others 1988) and recommended that a remediation focused on six metals (arsenic, copper, cadmium, lead, selenium, and zinc) should be conducted. The Navy completed four cleanup actions, referred to as remedial actions. Each of the four sites that were cleaned up is called a remedial action subsite, or RASS; they include RASSs 1 (210 acres), 2 (13 acres), 3 (71 acres), and 4 (13 acres). Remediation of these sites was limited because they include wetland areas that provide habitat for several threatened and endangered species. During the cleanup actions, only the most contaminated soils at each RASS were removed. Some contaminated soils were left in place in response to concerns associated with the destruction of extensive wetland habitat at the site.

To evaluate the success of the remedial actions and to assess migration and effects of contaminants left in place, the Navy and the USACE developed a monitoring plan as part of the remedial design (Lee and others 1989). The monitoring plan called for sampling and analyzing several parameters (both chemical and ecological) before, during, and after remedial actions were conducted.

The Navy completed 5 years of postremediation monitoring before initiating the postremediation five-year periodic review assessment (five-year review). The main purposes of the five-year review were to evaluate the implementation and the effectiveness of the selected remedy and to determine whether any additional actions are necessary. The five-year review was based on data collected during preremediation and postremediation monitoring, new data collected in October 2000 to fill data gaps identified during the development of the approach for the five-year review, a file review, a BERA, and a screening level human health risk assessment (HHRA). The findings and conclusions of the five-year review are contained in the draft final report issued in October 2002 (TtEMI 2002a).

The five-year review concluded that the Navy had selected and implemented remedial actions in a manner consistent with the National Contingency Plan. In addition, the restoration of remediated areas generally met success criteria and the Navy conducted the pre-, during-, and post-remediation monitoring required by the Record of Decision (ROD). The site is currently protective of human health based on continued use of the area as a buffer zone with limited access; concerns about trespassers in RASS 4 were noted. The 5- year review concluded that the remedy was not fully protective of the environment in RASSs 1 and 3, while it was protective of the environment in RASSs 2 and 4. The lack of protectiveness in RASS 1 was based on high levels of metals in ditches and sloughs in the southern portion of RASS 1 that may pose a risk to ecological receptors. In RASS 3, the lack of protectiveness determination was based on concerns about migration of contaminants from the Nichols Creek drainage to the wetland in RASS 1. The Navy is currently scoping a supplemental FS to address issues of protectiveness in RASSs 1 and 3.

The five-year review process also identified data gaps (described in Section 1.1.2) requiring additional data collection that are the subject of this SAP. The data gaps identified during the five-year review process are focused on further characterizing potential off-site sources of contamination to the Litigation Area or providing further chemical characterization of areas within the site.

1.1.4 Site Descriptions

NWS SDB Concord lies approximately 10 miles west of the confluence of the Sacramento and San Joaquin rivers. That confluence forms the delta region, where there are more than 600 miles of interconnected and meandering tidal waterways. Drainage from NWS SDB Concord flows almost exclusively northward into Suisun Bay. The Litigation Area is composed of tidal and nontidal wetlands and upland habitats.

1.1.4.1 RASS 1

RASS 1 is primarily a brackish, tidally influenced emergent marsh. The mean elevation of RASS 1 is 3 feet above mean sea level (msl). Wetland areas in RASSs 1 and 2, delineated by the USACE in 1991, were defined as those areas less than 5 feet in elevation (above msl). The elevation of RASS 1 is generally less than 5 feet; therefore, the entire area is a wetland. The marsh surface usually is damp to dry; however, after extreme high tides or heavy rains, from several inches to 2 feet of water is present throughout RASS 1. The RASS 1 marsh includes tidal slough channels and a network of mosquito abatement ditches that transect the site.

During a site inspection tour on July 27, 2001 (and during subsequent visits in fall 2001), the Navy, the contractors, and agency representatives observed an area of distressed vegetation in the remediated area of RASS 1 adjacent to the berm between GCC and Honeywell, Inc. and Navy property (TtEMI 2002a) (Figure 2 inset). This area of distressed vegetation measured approximately 40 feet by 120 feet. The cause of the distressed vegetation has not been determined; however, it may be related to chemical contamination migrating from the neighboring facility.

1.1.4.2 RASS 2

RASS 2 consists of brackish, tidally influenced, emergent marsh and an upland transition vegetation zone that extends south to the SPTC railroad track (Figure 2). The northwestern one-third of RASS 2 is a wetland having a mean elevation of approximately 3 feet above msl. The remaining two-thirds of RASS 2 consists of relatively flat uplands having a mean elevation of approximately 7 feet above msl. The wetland area has a thick marsh-grass surface layer, with a root mat some 2 to 4 inches thick at the soil horizon. The upland area has patchy vegetative cover, consisting of nonnative grass and shrubs.

1.1.4.3 RASS 3

RASS 3 is primarily an upland area. A small area of robust, emergent, tidally influenced marsh in the northwestern portion of RASS 3 was deepened and expanded during remediation activities to form a ponded area. Nichols Creek, an ephemeral stream, runs through RASS 3 to marsh area and subsequently drains into the extensive mosquito abatement ditch and slough system in RASS 1, which in turn discharges to Suisun Bay. The wetland area of RASS 3, delineated by the USACE in 1991, is roughly defined as the area encompassing Nichols Creek, which corresponds to the remediated area of RASS 3. Elevations in RASS 3 range from approximately 27 feet above msl in the southeastern area to approximately 5 feet above msl in the northwestern area. The upland area has patchy vegetative cover, consisting of nonnative grasses and shrubs. Seasonal rains and extreme high tides cause water to pond in the northwestern portion of the site.

The southeast side of RASS 3 is bordered by the CPC property. Observations were made during the five-year review that indicate a potential for contamination to migrate from CPC into Nichols Creek. Areas of soil erosion and surface water runoff exist at the CPC and Navy property border; plastic sheeting covering the large stockpile of contaminated soil at CPC was ripped, exposing contaminated soil to the weather. The extent of groundwater-surface water interaction at the CPC and Nichols Creek border on Navy property is not known (TtEMI 2002a).

Nichols Creek in RASS 3 is an area of uncontrolled migration of contaminants in soil and surface water because the creek is actively eroding areas of contaminated soil; the areas of most extensive erosion are on railroad-owned properties.

Total PCBs at concentrations up to 1,500 micrograms per gram (μg/g) were found along the SPTC railroad track in RASS 3. As noted in Section 1.1.2.4, additional characterization of the spatial distribution of PCBs along the SPTC railroad track and Nichols Creek in RASS 3 will be conducted during this investigation (Figure 2).

1.1.4.4 RASS 4

RASS 4 is primarily an upland area, with a small palustrine, robust, emergent marsh in the eastern portion of the site (O'Neil 1988). The nontidal wetland area of RASS 4, delineated by the USACE in 1991, is roughly defined as the area encompassing the easternmost portion of the RASS, directly north of Port Chicago Highway (Figure 2). The elevation of RASS 4 ranges from approximately 3 feet above msl in the eastern wetland area to a mean of approximately 20 feet above msl in the western upland area. The upland area has patchy vegetative cover, consisting of grass and bushes. Heavy rains may cause several inches of water to pond at the eastern portion of the site.

During the site inspection tour in July 2001, evidence was observed that trespassers had gained access to RASS 4. The site is not fenced on the northern side, locks on the gates were broken, and motorcycle tracks and dumped refuse were observed in RASS 4. An unusual semi-lithified or ashy soil was also observed in RASS 4 at the same time. The chemical composition of this soil material is not known.

1.1.5 Environmental Setting

The following sections provide a brief description of the environmental setting of the Litigation Area including geology and soils, hydrology, groundwater, and ecology.

1.1.5.1 Geology and Soils

The geology at the Litigation Area is dominated by Pleistocene and Holocene geomorphology. The subsurface zone consists of interfingering alluvial and estuarine depositional environments. Footslopes, flood plains, and marsh or wetland areas of Quaternary age characterize the Litigation Area. Terraced Pleistocene alluvial fans and flood plain deposits form the footslopes. Pleistocene deposits are overlain by Holocene flood plain deposits that consist of unconsolidated sands, silts, gravels, and clays.

In the wetland areas adjacent to Suisun Bay, Holocene alluvial material has been overlain by fine-grained silt and clay, mixed with organic materials that make up what is locally known as Bay Mud. The wetland soil is Joice Muck series. In the system of the National Cooperative Soil Survey, the wetland soil is clastic, euic, thermic Terric Medisaprists. The upland soil (on terrace deposits of alluvium) is classified as Antioch loam (fine, montmorillonite, thermic Typic natrixeralfs) or Capay clay (fine, montmorillonite, thermic Typic chromoxererts).

The Bay Muds are further defined as younger Bay Mud and older Bay Mud. The lithology of Quaternary older Bay Mud includes stiff, gray, silty clay, sand, and gravel. Younger Bay Mud is a dark gray to dark brown organic clay that contains a minor amount of peat and clayey sand. The younger Bay Mud is estuarine and marine silty clay that commonly ranges from normally consolidated to underconsolidated and soft to weak and varies in thickness from 15 to 50 feet. Most surface areas of RASS 1 and a portion of RASS 2 are primarily underlain by younger Bay Mud and silty peat, a highly compressible fibrous soil that contains 30 to 75 percent organic materials. Both Bay Mud and silty peat are typical of bay-margin marshes.

In the upland areas of RASSs 3 and 4, the upper 6 inches of soil is soft to medium-stiff, wet to saturated, clayey silt. The surface soil in most of RASS 3 is dry and very hard in the dry season.

1.1.5.2 Hydrology

The Litigation Area, which lies on the southern margin of Suisun Bay, includes more than 200 acres of tidal marsh. A small seasonal stream (Nichols Creek) drains a local watershed in the Los Medanos Hills south of the site and discharges into the marsh. The hydrology of the marsh is characterized by the complex interplay of tides, currents, surface water runoff, evapotranspiration, and weather.

Surface water bodies in the Litigation Area consist of the natural slough (referred to as Lost Slough) and tributaries that meander throughout the marsh, the network of man-made mosquito abatement ditches in RASS 1, a ponded area that was created by remedial action at the west end of RASS 3, and a seasonal stream (Nichols Creek) that drains into the pond in RASS 3 and discharges to the RASS 1 wetlands at low tide. RASS 1 is flat marsh incised by a natural slough, tributaries, and an extensive network of mosquito abatement ditches. The RASS 3 pond is hydraulically connected to RASS 1; both are tidally influenced. The base of the RASS 3 pond is elevated relative to the slough and ditches, but a submerged embankment prevents complete drainage of the pond. Nichols Creek is a narrow, seasonal creek that drains a small, undeveloped upland watershed of approximately 1 square mile in the Los Medanos Hills south of the site and passes along the western boundary of the property of the Chemical and Pigment Company before entering RASS 3 (Cullinane and others 1988).

1.1.5.3 Groundwater

Groundwater at the Litigation Area occurs in a shallow unconfined water-bearing zone that is predominantly composed of silty clays. Water occurs at elevations of approximately 3 to 5 feet above msl over most of the Litigation Area. Because of changes in surface elevations, depth to water ranges from about 5 feet below grade in the tidal marsh area to 45 feet below grade in the extreme southern part of the Litigation Area. Near the tidal marsh, groundwater generally flows to the northwest, but a persistent groundwater mound in the area where Nichols Road crosses the railroad tracks causes groundwater to flow to the west and southwest in the southern part of the Litigation Area. Groundwater flow in RASS 4 is highly variable and has been directed toward the northeast, south, southeast, and west at various times, with no apparent seasonal cause of changes in flow direction.

Few water supply wells are present in the area, and satisfactory yields can generally be obtained only by drilling deeper bedrock wells. Groundwater generally exhibits relatively high concentrations of total dissolved solids (TDS), hardness, chlorides, and iron, especially when compared with those parameters for available surface water in the area. Because of the relatively high salinity of groundwater throughout most of the Litigation Area, the groundwater is not a potential drinking water source (PRC Environmental Management, Inc. [PRC] 1997a).

1.1.5.4 Ecology

Suisun Bay is a transition zone between the marine influence of San Francisco Bay and the freshwater influence of the Sacramento and San Joaquin rivers. The lower wetland portion of the Litigation Area, particularly in RASSs 1 and 2, is a dynamic marsh habitat characterized by vegetation that tolerates frequent inundation by brackish water. The drier upland portions of the Litigation Area, particularly RASSs 3 and 4, are essentially disturbed grasslands, except for a small freshwater marsh in RASS 4 and a small pond at the western end of RASS 3. The RASS 3 pond is tidally influenced and has been colonized by plant and animal species characteristic of freshwater and brackish marshes. A more complete description of habitats and species is presented in the Qualitative Ecological Assessment (QEA) (PRC 1997b).

Several threatened and endangered species are known to occur at NWS SBD Concord. Species of concern observed at the Litigation Area include salt marsh harvest mouse (federally and state-listed endangered species), California Black Rail (state-listed threatened species), Delta tule pea, soft bird's beak, Mason's lilaeopsis, and Suisun marsh aster. A more complete description of special-status species observed or expected to occur at the Litigation Area is provided in the QEA (PRC 1997b).

1.1.6 Summary of Previous Investigations

As described in Section 1.1.3, the Navy acquired the Litigation Area property in the 1970s from several different owners. This area was subsequently found to be contaminated with metals resulting primarily from waste disposal activities and historic spills from off-site neighboring chemical companies; some smaller on-site historic (non-Navy) sources were also located in several parcels. RASS 1 through 4 were identified in an RI/FS completed by the USACE in 1988; the RI identified six metals (arsenic, cadmium, copper, lead, selenium, and zinc) as chemicals of concern, and the FS recommended remedial alternatives and soil cleanup criteria for each RASS. On April 6, 1989, the Navy issued a final remedial action plan (RAP) and signed a ROD.

The remedy identified in the RAP and ROD included active removal of the most contaminated soil from a portion of each site and passive remediation and long-term monitoring of contaminants left in place. Because the Litigation Area includes wetlands that provide habitat for several threatened or endangered species, some contaminated soil was left in place to avoid destroying sensitive habitat. Active remediation (removal and disposal of contaminated soil) was conducted between 1992 and 1995; site revegetation was completed by 1996. The Navy implemented a monitoring plan as part of its remedial design to assess migration and effects of contaminants left in place. A QEA was conducted in 1996 to evaluate the nature and extent of organic contaminants and to confirm that the six metals of concern were the primary ecological risk drivers at the site (PRC 1997b). The Navy completed 5 years of postremediation monitoring before initiating the five-year review in 2000.

The five-year postremediation review is a statutory review required under CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986, in cases where (1) contaminants are left in place and (2) the ROD was signed after October 1986. The components of the five-year review were developed in collaboration with the regulatory and trustee agencies and documented in a work plan. The main purpose of the five-year review was to evaluate the implementation and the effectiveness of the selected remedy and to determine whether any additional actions are necessary. The Navy also agreed to conduct a screening-level HHRA and a BERA to evaluate whether metals contamination left at the site presents an ongoing threat. The five-year review was based on data collected during preremediation and postremediation monitoring, the QEA conducted from 1995 to 1997, and new data collected in October 2000 to fill data gaps identified during the development of the approach for the five-year review.

Based on the findings of the five-year review, the Navy acknowledged that the remedy is not fully protective of the environment in RASSs 1 and 3. However, evidence exists that the adjoining chemical company and railroad properties may be ongoing sources of contamination to RASSs 1 and 3. The Navy proposed to conduct additional investigation to further evaluate ongoing off-site sources and to resolve any on-site data gaps before addressing concerns about the protectiveness of the remedy within the Litigation Area (TtEMI 2002a). This additional investigation to evaluate the data gaps identified during the five-year review assessment is the subject of this SAP.

1.1.7 Principal Decision Makers

Principal decision makers include the Navy, regulatory and trustee agencies, and the general public. The data collected from this project will be used to evaluate data gaps identified during the five-year review process and determine the appropriate future action for the Litigation Area.

1.1.8 Technical or Regulatory Standards

Results of soil, sediment, and groundwater analytical samples collected during this investigation will be compared to analytical results collected as part of the five-year monitoring program to document changes in site conditions or concentrations that exceed previously measured values. In some cases, analytical results will be compared to available toxicity-based benchmarks or criteria. For purposes of identifying project-required reporting limits (PRRL), the following criteria or benchmarks were selected for this investigation:

- Toxicological benchmarks for soil developed by the Oak Ridge National Laboratory (ORNL) for plants, invertebrates, and wildlife (Efroymson and others 1997 a, b, and c)
- Effects Range-Low toxicological benchmarks for sediment (Long and others 1995) (Long and Morgan 1990)
- The lower of the freshwater or saltwater chronic Ambient Water Quality Criteria (AWQC) developed by the EPA. For organic chemicals, the new AWQC (EPA 2002) were used; for inorganic chemicals at the Litigation Area, the Navy and regulatory agencies had identified appropriate water quality screening benchmarks based on previously promulgated standards (EPA 1998, 2000a; RWQCB 1995)

Screening benchmarks and PRRLs are provided in Appendix D.

1.2 PROJECT DESCRIPTION

The following subsections discuss the objectives and measurements of the project. Table 2 presents a schedule of sampling, analysis, and reporting.

1.2.1 Project Objectives

As stated in Section 1.1, the objective of the data gaps evaluation is to collect information needed to evaluate the five areas or issues of concern identified as data gaps during the five-year review process. The five data gaps and their respective project objectives are described below.

A. Distressed Vegetation Area in RASS 1

Determine whether the area of distressed vegetation in RASS 1 is the result of chemical migration from the GCC or Honeywell, Inc. facilities into remediated marsh soils on Navy property.

B. Groundwater-Surface Water Interactions at Chemical and Pigment Company Border

Evaluate the groundwater-surface water interaction at the border between Navy property and the northwestern corner of the CPC site along Nichols Creek and the likelihood that metals are migrating from groundwater beneath CPC property onto Navy property.

C. Litigation Area Groundwater Well Sampling

Determine if Litigation Area groundwater quality or groundwater flow has changed significantly from conditions last measured in October 1996.

D. RASS 3 Polychlorinated Biphenyl Sampling

Determine if PCBs are present in soil along the SPTC railroad property in RASS 3, in areas where previous sampling showed elevated concentrations, or at selected locations along Nichols Creek between CPC property and SPTC railroad tracks at concentrations greater than 1.5 milligrams per kilogram (mg/kg).

E. RASS 4 Semi-lithified Soil Sampling

Determine if total metals, semivolatile organic compounds (SVOC), PCBs, or pesticides are present in semi-lithified soils observed in RASS 4 above previously measured concentrations and/or available toxicological benchmarks.

TABLE 2

PROPOSED IMPLEMENTATION SCHEDULE FOR SAMPLING, ANALYSIS, AND REPORTING

Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Milestone	Due Date	Anticipated Date
Internal draft SAP	March 5, 2003	March 5, 2003
Navy review of SAP	14 calendar days after internal draft SAP is submitted for review	March 17, 2003
Draft SAP to regulatory agencies	12 calendar days after Navy comments are received or March 29, 2003	March 28, 2003
Regulatory agency review of SAP	60 calendar days after draft SAP submitted for agency review	May 28, 2003
Internal final SAP	15 calendar days after all regulatory agency comments are received	June 12, 2003
Navy review of Final SAP	15 calendar days after internal draft SAP is submitted for review	June 27, 2003
Final SAP to regulatory agencies	15 calendar days after Navy comments are received	July 12, 2003
Data gaps evaluation field investigation	Completed within 60 calendar days after draft final SAP submitted to regulatory agencies	August 26, 2003
Internal draft TER	45 calendar days after field investigation completed and laboratory data validated	December 1, 2003
Navy review of Internal draft TER	21 days after internal draft is submitted for review	December 22, 2003
Draft TER submitted to agencies	21 days after receipt of Navy comments	January 12, 2004
Agency review of Draft TER	30 days after submittal	February 11, 2004
Internal draft RTC	14 days after receipt of comments	February 25, 2004
Navy review of internal draft RTC	14 days after receipt of RTC	March 11, 2004
Submit RTC to agencies	7 days after Navy review completed	March 18, 2004
Internal final TER to Navy	30 days after receipt of agency comments	March 21, 2004
Navy review of internal final TER	21 days after receipt of internal version	April 11, 2004
Draft final TER to agencies	14 days after receipt of Navy comments	May 1, 2004

Notes:

RTC Response to comments
SAP Sampling and analysis plan
TER Technical Evaluation Report

1.2.2 Project Measurements

To meet the project objectives, the following measurements will be conducted to address the data gaps:

A. **Distressed Vegetation Area in RASS 1.** Surface (0 to 0.5 feet below ground surface [bgs]) and subsurface (1 to 1.5 feet bgs) samples will be collected from 12 locations (total of 24 samples) along transects both parallel and perpendicular to the berm adjacent to the area of distressed vegetation. The sampling will employ random starting positions and the spacing and alignment of samples will allow for an assessment of spatial trends in metal concentrations using a nonparametric statistical test for monotonic trends (Mann-Kendall test). The soil samples will be analyzed for total metals, pH, and total organic carbon (TOC).

   Grab groundwater samples will be collected from a subset of 9 soil-sampling locations. The grab groundwater samples will be filtered and analyzed for dissolved metals and pH.

B. **Groundwater-Surface Water Interactions at Chemical and Pigment Company Border.** One new groundwater monitoring well will be installed on Navy property near the northwestern border of the CPC. Detailed lithologic logging of the well will be performed to assess the presence of a perched zone or other preferential flow pathway.

   Synoptic water-level measurements will be taken for the new Navy well and selected CPC wells to determine the flow direction in the perched zone and shallow aquifer.

   The elevation of Nichols Creek will be surveyed and a staff gauge will be installed to allow periodic measurement of surface-water levels. Groundwater and surface-water levels will be measured during extreme weather conditions in late summer and late winter (if possible) to evaluate the intra-annual range in flow conditions (see Figure 2).

C. **Litigation Area Groundwater Well Sampling.** One round of groundwater sampling will be conducted to measure concentrations of total metals in 17 existing wells and the single new well to be installed near the CPC border (Figure 2), for a total of 18 wells. Samples will be analyzed for total metals (unfiltered) to allow comparisons with previous data.

D. **RASS 3 Polychlorinated Biphenyl Sampling.** A total of 16 soil samples will be collected for analysis of seven Arolcors (PCB mixtures). Six surface (0 to 0.5 feet bgs) samples will be collected along a corridor adjacent to the SPTC railroad tracks. Sampling will employ a random starting position for the first sample, and subsequent samples will be collected at approximately equal distances from one another along an 1,800 foot transect parallel to the railroad tracks. Two surface samples will be collected along Nichols Creek at staggered locations between the border of the CPC property and the railroad tracks. Four surface (0 to 0.5 feet bgs) and four subsurface (1 to 1.5 feet bgs) soil samples will be collected from a triangular array (one location at each of the corners and one location in the center of the triangle), centered on location R03SS214, where elevated concentrations of PCBs were previously measured (Figure 2).

E. **RASS 4 Semi-lithified Soil Sampling.** Three surface soil samples will be collected in the area where motorcycle tracks have been observed near the remediated portion of RASS 4; this is the area where semi-lithified soil was observed during the July 2001 site tour (Figure 2). The soil samples will be analyzed for total metals, SVOCs, Aroclors, pesticides, TOC, and pH.

1.3 QUALITY OBJECTIVES AND CRITERIA

The following sections present the data quality objectives (DQO) and measurement quality objectives (MQO) identified for this project.

1.3.1 Data Quality Objectives

DQOs are qualitative and quantitative statements developed through the seven-step DQO process (EPA 2000b, 2000c). The DQOs clarify the study objective, define the most appropriate data to collect and the conditions under which to collect the data, and specify tolerable limits on decision errors that will be used as the basis for establishing the quantity and quality of data needed to support decision-making. The DQOs are used to develop a scientific and resource-effective design for data collection. The seven steps of the DQO process for this project are presented in Table 3.

1.3.2 Measurement Quality Objectives

All analytical results will be evaluated in accordance with precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters to document the quality of the data and to ensure that the data are of sufficient quality to meet the project objectives. Of these PARCC parameters, precision and accuracy will be evaluated quantitatively through the collection of the quality control (QC) samples listed in Table 4. Precision and accuracy goals for these QC samples are listed in Appendix A.

The following sections describe each of the PARCC parameters and how they will be assessed within this project.

1.3.2.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same property under similar conditions. Combined field and laboratory precision is evaluated by collecting and analyzing field duplicates and then calculating the variance between the samples, typically as a relative percent difference (RPD).

$$\text{RPD} = \frac{|A - B|}{(A + B)/2} \times 100\%$$

where: A = first duplicate concentration
B = second duplicate concentration

TABLE 3

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 1: State the Problem

A. Distressed Vegetation Area in Remedial Action Subsites 1

An area of distressed vegetation was observed in the remediated portion of remedial action subsites (RASS) 1 along the berm separating the General Chemical Company (GCC) facility and the Honeywell, Inc. alum waste ponds from the Navy's property. A file review indicated high groundwater and soil concentrations of metals and low pH at the GCC facility, and groundwater flows west toward the Litigation Area.

A focused investigation is required to determine whether the area of distressed vegetation is the result of chemical migration from the GCC or Honeywell, Inc. facilities into remediated marsh soils on Navy property.

B. Groundwater-Surface Water Interactions at Chemical and Pigment Company Border

Historic data show high concentrations of zinc in groundwater samples collected from wells in the center and the northwestern corner of the Chemical and Pigment Company (CPC) in 1998. This contamination may be flowing toward Navy property and surfacing into Nichols Creek. Groundwater in this area flows north or west based on data from wells located on Naval Weapons Station Seal Beach Detachment (NWS SBD) Concord property. Groundwater flows to the west in the perched zone and to the northeast in the deeper sand body based on reports submitted for CPC. The extent of groundwater-surface water interaction in Nichols Creek near the CPC border is unknown.

A focused groundwater investigation on Navy property bordering the northwestern corner of the CPC along Nichols Creek and on CPC property is needed to evaluate the groundwater-surface water interaction in this area and the likelihood that groundwater at CPC is adversely affecting Nichols Creek or the Navy's property.

C. Litigation Area Groundwater Well Sampling

The Navy's most recent sampling of groundwater wells (11 of 22 wells) at the Litigation Area occurred in October 1996. Additional sampling of groundwater wells is needed to determine whether flow conditions or groundwater quality have changed since the previous sampling event in October 1996.

D. RASS 3 Polychlorinated Biphenyl (PCB) Sampling

The Baseline Ecological Risk Assessment (BERA) conducted as part of the five-year review concluded that PCBs did not pose unacceptable risk to ecological receptors. However, the BERA did acknowledge that insufficient information existed for areas within RASS 3 along the Southern Pacific Transportation Company (SPTC) railroad track property to adequately characterize risk for this portion of the site. In 1996, total PCBs were detected at a concentration of 480 micrograms per kilogram (µg/kg) at a single location in RASS 3 along the SPTC railway tracks. In addition, total PCBs were detected at concentrations ranging from 70 to 1,500 µg/kg in three confirmation samples collected within a few meters of the original location. The regulatory agencies have also recommended that PCB concentrations be measured at several locations along Nichols Creek between the CPC and SPTC railroad property.

Additional sampling and characterization of PCB concentrations is needed for areas along the SPTC railroad tracks, in areas of RASS 3 where previous sampling revealed elevated concentrations, and at several locations along Nichols Creek between the CPC and SPTC property.

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 1: State the Problem
E. RASS 4 Semi-lithified Soil Sampling During a site inspection tour in July 2002, an area of semi-lithified or ashy soil was observed near the RASS 4 remediated area in motorcycle tracks left by trespassers. The unusual nature of the soil raised questions about its source and chemical composition. The Navy reviewed historic aerial photographs from 1957 to 1986 to determine whether previous sampling efforts (pre- and postremediation) were conducted in the area of semi-lithified soil. It was not possible to determine whether previous samples of the semi-lithified soil were collected. Additional sampling of this area of semi-lithified soil is needed to fully characterize the chemical composition of this material.
STEP 2: Identify the Decisions
A. Distressed Vegetation Area in RASS 1 Do total metal concentrations in soil and filtered grab groundwater, pH, and information on groundwater flow provide sufficient evidence to conclude whether metals are migrating from the GCC and Honeywell, Inc. properties onto Navy property? **B. Groundwater-Surface Water Interactions at Chemical and Pigment Company Border** Do the lithology and water-level measurements support a hydrologic connection between CPC groundwater and adjacent Nichols Creek? **C. Litigation Area Groundwater Well Sampling** Has groundwater quality or groundwater flow changed significantly from conditions last measured in October 1996? **D. RASS 3 Polychlorinated Biphenyl Sampling** Are PCBs present in soil along the SPTC railroad property in RASS 3, in areas where previous sampling showed elevated concentrations, or at selected locations along Nichols Creek between CPC property and SPTC railroad tracks at concentrations greater than 1,500 µg/kg? **E. RASS 4 Semi-lithified Soil Sampling** Are total metals, semivolatile organic compounds (SVOC), PCBs, or pesticides present in semi-lithified soils observed in RASS 4 above previously measured concentrations and/or available toxicological benchmarks?

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 3: Identify Inputs to the Decisions
A. Distressed Vegetation Area in RASS 1 • Surface and subsurface soil samples from locations parallel and perpendicular to the area of the berm where distressed vegetation has been observed and outside of that immediate area. • Grab groundwater samples (filtered and analyzed for dissolved metals) from a subset of the locations where soil samples are collected. • Other information, such as geologic cross-sections from file reviews of neighboring facilities. **B. Groundwater-Surface Water Interactions at Chemical and Pigment Company Border** • Water-level measurements from one new well established on Navy property near the border of the CPC facility detailed lithology and well-construction logs for CPC and the new well on Navy property. • Groundwater analytical data and potentiometric elevations for CPC wells (if available). • Synoptic water-level measurements in a subset of wells on both Navy and CPC property. • Survey elevations for Nichols Creek and groundwater and surface water measurements during extreme weather conditions in late summer and late winter (if possible). **C. Litigation Area Groundwater Well Sampling** • One round of groundwater sampling to measure total metals concentrations in 17 existing and 1 new well using low-flow methods (if possible). **D. RASS 3 Polychlorinated Biphenyl Sampling** • Surface soil samples collected along a corridor adjacent to the SPTC railroad tracks and at several locations along Nichols Creeks between the CPC property and the SPTC railroad tracks. • Surface and subsurface soil samples collected near locations where elevated PCB concentrations were previously reported. **E. RASS 4 Semi-lithified Soil Sampling** • Surface soil samples from areas along the motorcycle tracks near the remediated portion of RASS 4 where semi-lithified materials have been observed.

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 4: Define Study Boundaries
The spatial boundaries for each of the data gaps investigations are as follows: **<u>Distressed Vegetation Area in RASS 1</u> –** Investigation will focus on an area approximately 120 by 40 feet in the remediated portion of RASS 1 along an earthen berm that separates the Navy and GCC and Honeywell, Inc. properties. Sampling transects extend approximately 25 feet outside of the immediate distressed vegetation area with one sample location at the margin of Suisun Bay, approximately 1,300 feet north of the area. **<u>Groundwater-Surface Water Interactions at the CPC Border</u> –** Investigation will focus on an area of Navy property adjacent to the northwestern corner of the CPC, as well as on CPC property. **<u>Litigation Area Groundwater Well Sampling</u>** – Investigation will include a subset of 18 wells at Litigation Area. **<u>RASS 3 PCB Sampling</u> –** Investigation will include an approximately 1,800 foot corridor parallel to the STPC railroad tracks in RASS 3; locations along Nichols Creek, between the CPC property and the STPC railroad tracks; and in an area near location R03SS214, where elevated concentrations of PCBs have previously been measured. **<u>RASS 4 Semi-lithified Soil Sampling</u> –** Investigation will focus on an area of semi-lithified soil located in a series of motorcycle tracks near the remediated portion of RASS 4. The temporal boundary of the data gaps investigations will be a 16-month period, between February 2003 and May 2004.
STEP 5: Develop Decision Rules
A. Distressed Vegetation Area in RASS 1 A weight-of-evidence (WOE) approach will be used to determine whether offsite chemical migration may be responsible for the area of distressed vegetation observed on Navy property. The following lines of evidence will be used as indicators that offsite chemical migration is a likely causal factor: • Elevated concentrations of metals in soil and grab groundwater within the area of distressed vegetation compared to outside the area of distressed vegetation. • Significant decreasing trend in metal concentrations, measured from locations adjacent to the berm bordering Navy and GCC and Honeywell, Inc. property and within the area of distressed vegetation, to locations extending outward from the affected area. • Confirmation that groundwater flows from beneath the GCC and Honeywell, Inc. properties in a direction that would lead onto Navy property and, therefore, has the potential to transport chemical contaminants to the area where distressed vegetation has been observed. • Demonstration that concentrations of metals in the area of distressed vegetation exceed average concentrations measured from long-term monitoring studies in the remediated area of RASS 1. If a preponderance of the evidence suggests that offsite migration is a likely explanation for the area of distressed vegetation observed in the remediated portion of RASS 1, then the Navy will work with the regulatory agencies to pursue an appropriate course of action. If a preponderance of the evidence does not suggest that offsite migration of chemicals is a likely causal factor, then the Navy will conclude that other factors, possibly unrelated to chemical stressors, are responsible for the area of distressed vegetation observed in RASS 1. The Navy will also discuss the implications of this finding with the regulatory agencies and, if necessary, pursue an appropriate course of action.

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 5: Develop Decision Rules
B. Groundwater-Surface Water Interactions at Chemical and Pigment Company Border If a preferential flow pathway exists below the water table that connects the subsurface at CPC with Nichols Creek, and if the potentiometric surface shows groundwater flow toward Nichols Creek, then it will be concluded that contaminated groundwater from the CPC discharges to Nichols Creek. If a preferential flow pathway and groundwater flow toward Nichols Creek cannot be confirmed, then it will be concluded that contaminated groundwater from CPC does not discharge into Nichols Creek. **C. Litigation Area Groundwater Well Sampling** If comparison of the new data with the previous round of post-remediation samples collected in October 1996 shows a pattern of significant increase in metal concentrations, then more focused groundwater monitoring may be needed. A weight-of-evidence process will be followed to determine if a pattern of significant increase is indicated for one or more chemicals or wells, and will include the following lines of evidence: 1) a significant increase in one or more chemicals within an individual well; 2) a significant increase in one or more chemicals in two or more wells; and 3) in the event that chemical concentrations have increased in a series of wells, graphical (mapping) and statistical testing (Mann-Kendall test for monotonic trends) will be conducted to evaluate spatial trends. A significant increase will be defined as an increase over the post-remediation baseline for metal concentrations measured during October 1996, taking into account normal variation in metal concentrations. Since only a single round of measurements are available for the post-remediation data, the previous four quarters of pre-remediation data (collected during 1993 to 1994) will be used to define an expected range for the variability of concentrations for each metal. The coefficient of variation (standard deviation/mean) will be used as a relative measure of variability. Any concentration measured in 2003 that exceeds the 1996 baseline plus 1.5 times the coefficient of variation for the 1993-1994 data, will be interpreted as a significant increase. If no significant increases are shown for chemicals in individual or multiple wells, then it will be concluded that metal concentrations in groundwater have not increased since the last round of sampling in October 1996. **D. RASS 3 Polychlorinated Biphenyl Sampling** If concentrations of total Aroclors (sum of seven Aroclor compounds) greater than 1,500 µg/kg are found, then existing food-chain models will be used to assess the risk to higher-level ecological receptors previously evaluated at the site. If all concentrations of total Aroclors are below 1,500 µg/kg, then no further action will be taken, and it will be concluded that potential risk from PCBs has been adequately characterized at the Litigation Area and is acceptable. **E. RASS 4 Semi-lithified Soil Sampling** If concentrations of chemicals are above previously measured concentrations in RASS 4 then an additional evaluation of risk may be needed. If concentrations of chemicals do not exceed previously measured concentrations in RASS 4 or available toxicological benchmarks, then no further action will be taken, and it will be concluded that chemical concentrations in the observed area of semi-lithified soil do not pose an unacceptable risk.

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 6: Specify Tolerable Limits on Decision Errors
The number of samples for further characterizing selected locations of the Litigation Area as part of this data gaps investigation was determined based on best professional judgment. Because there is no probability-based theory for estimating sampling errors for judgmental designs, it is not possible to specify quantitative limits for Type I and Type II decision errors. To the extent practical, sampling locations will be based on random starting positions to assure that samples will be unbiased and, therefore, can be treated as representative point-locations within each of the areas investigated.
STEP 7: Optimize the Sampling Design
A. Distressed Vegetation Area in RASS 1 Surface (0 to 0.5 feet below ground surface [bgs]) and subsurface (1 to 1.5 feet bgs) samples will be collected from 12 locations (total of 24 samples) along transects both parallel and perpendicular to the berm adjacent to the area of distressed vegetation. The sampling will employ random starting positions and the spacing and alignment of samples will allow for an assessment of spatial trends in metal concentrations using a nonparametric statistical test for monotonic trends (Mann-Kendall test). The soil samples will be analyzed for total metals, pH, and total organic carbon (TOC). Grab groundwater samples will be collected from a subset of 9 soil-sampling locations. The grab groundwater samples will be filtered and analyzed for dissolved metals and pH. **B. Groundwater-Surface Water Interactions at Chemical and Pigment Company Border** One new groundwater monitoring well will be installed on Navy property near the northwestern border of the CPC. Detailed lithologic logging of the well will be performed to assess the presence of a perched zone or other preferential flow pathway. Synoptic water-level measurements will be taken for the new Navy well and selected CPC wells to determine the flow direction in the perched zone and shallow aquifer. The elevation of Nichols Creek will be surveyed and a staff gauge will be installed to allow periodic measurement of surface-water levels. Groundwater and surface-water levels will be measured during extreme weather conditions in late summer and late winter (if possible) to evaluate the intra-annual range in flow conditions. **C. Litigation Area Groundwater Well Sampling** One round of groundwater sampling will be conducted to measure concentrations of total metals in 17 existing and 1 new well.

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

STEP 7: Optimize the Sampling Design
D. RASS 3 Polychlorinated Biphenyl (PCB) Sampling A total of 16 soil samples will be collected for analysis of seven Arolcors (PCB mixtures). Six surface (0 to 0.5 feet bgs) samples will be collected along a corridor adjacent to the SPTC railroad tracks. Sampling will employ a random starting position for the first sample, and subsequent samples will be collected at approximately equal distances from one another along an 1,800 foot transect parallel to the railroad tracks. Two surface samples will be collected along Nichols Creek at staggered locations between the border of the CPC property and the railroad tracks. Four surface (0 to 0.5 feet bgs) and four subsurface (1 to 1.5 feet bgs) soil samples will be collected from a triangular array (one location at each of the corners and one location in the center of the triangle), centered on location R03SS214, where elevated concentrations of PCBs were previously measured. **E. RASS 4 Semi-lithified Soil Sampling** Three soil samples will be collected along the motorcycle tracks near the remediated portion of RASS 4 where areas of semi-lithified materials have been observed. The samples will be analyzed for total metals, volatile organic compounds (VOC), Aroclors, pesticides, TOC, and pH.

TABLE 4

QUALITY CONTROL SAMPLES FOR PRECISION AND ACCURACY

Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

<table>
<tr><th>QC Type</th><th>Precision</th><th>Accuracy</th><th>Frequency</th></tr>
<tr><td rowspan="3">Field QC</td><td rowspan="3">Field Duplicate</td><td>None</td><td>Field Duplicate = 10 percent of samples (groundwater)</td></tr>
<tr><td>Equipment Rinsate</td><td>Equipment Rinsate = 1/day/piece of equipment used for sampling</td></tr>
<tr><td>Source Water Blank</td><td>Source Water Blank = 1/source of water used for the final decontamination rinse</td></tr>
<tr><td rowspan="5">Laboratory QC</td><td rowspan="5">MS/MSD RPD</td><td>MS/MSD %R</td><td>MS/MSD = 1/20 samples (soil),
1/20 samples (groundwater)</td></tr>
<tr><td>Method Blanks</td><td>Method Blank = 1/20 samples</td></tr>
<tr><td>LCS or Blank Spikes</td><td>LCS or Blank Spikes = 1/20 samples</td></tr>
<tr><td>Surrogate Standards %R</td><td>Surrogate Standards = Every sample for organic analysis by GC</td></tr>
<tr><td>Internal Standards %R</td><td>Internal Standards = Every sample for organic analysis by GC</td></tr>
</table>

Notes:

%R	Percent recovery
GC	Gas chromatography
LCS	Laboratory control sample
MS/MSD	Matrix spike/matrix spike duplicate
QC	Quality control
RPD	Relative percent difference

Field sampling precision is evaluated by analyzing field duplicate samples. Because it is not practical to obtain true field duplicate soil samples, field duplicates will only be collected for groundwater for this project.

Laboratory analytical precision is evaluated by analyzing laboratory duplicates or matrix spikes (MS) and matrix spike duplicates (MSD). For this project, MS/MSD samples will be generated for all analytes. The results of the analysis of each MS/MSD pair will be used to calculate an RPD for evaluating precision.

1.3.2.2 Accuracy

Accuracy is the degree of agreement between an analytical measurement and a reference accepted as a true value. The accuracy of a measurement system can be affected by errors introduced by field contamination, sample preservation, sample handling, sample preparation, and analytical techniques. A program of sample spiking will be conducted to evaluate laboratory accuracy. This program includes analysis of the MS and MSD samples, laboratory control spikes (LCS) or blank spikes, surrogate standards, and method blanks. MS and MSD samples will be prepared and analyzed at a frequency of 5 percent for soil samples. LCS or blank spikes are also analyzed at a frequency of 5 percent. Surrogate standards, where available, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the percent recovery for evaluating accuracy.

$$\text{Percent Recovery} = \frac{S - C}{T} \times 100$$

where S = Measured spike sample concentration
C = Sample concentration
T = True or actual concentration of the spike

Appendix A presents accuracy goals for the data gaps investigation based on the percent recovery of matrix and surrogate spikes. Results that fall outside the accuracy goals will be further evaluated on the basis of other QC samples.

1.3.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, variations in a parameter at a sampling point, or an environmental condition that they are intended to represent. For this project, representative data will be obtained through careful selection of sampling locations and analytical parameters. Representative data will also be obtained through proper collection and handling of samples to avoid interference and minimize contamination.

Representativeness of data will also be ensured through the consistent application of established field and laboratory procedures. Field blanks (if appropriate) and laboratory blank samples will be evaluated for the presence of contaminants to aid in evaluating the representativeness of sample results. Data determined to be nonrepresentative, by comparison with existing data, will be used only if accompanied by appropriate qualifiers and limits of uncertainty.

1.3.2.4 Completeness

Completeness is a measure of the percentage of project-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability are exceeded. When all data validation is completed, the percent completeness value will be calculated by dividing the number of useable sample results by the total number of sample results planned for this investigation.

As discussed further in Section 4.2, completeness will also be evaluated as part of the data quality assessment process (EPA 2000d). This evaluation will help determine whether any limitations are associated with the decisions to be made based on the data collected.

1.3.2.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

1.3.2.6 Detection and Quantitation Limits

The method detection limit (MDL) is the minimum concentration of an analyte that can be reliably distinguished from background noise for a specific analytical method. The quantitation limit represents the lowest concentration of an analyte that can be accurately and reproducibly quantified in a given sample matrix. PRRL are contractually specified maximum quantitation limits for specific analytical methods and sample matrices, such as soil or water, and are typically several times the MDL to allow for matrix effects. PRRLs, which are established by TtEMI in the scope of work for subcontract laboratories, are set to establish minimum criteria for laboratory performance; actual laboratory quantitation limits may be substantially lower.

For this project, standard analytical methods have been selected so that the PRRLs for target analytes are generally below the applicable regulatory screening criteria or available toxicity-based benchmark. For aqueous media (groundwater and quality control samples) the lower of the freshwater or marine chronic AWQC were used to assess PRRLs (Marshack 2000; EPA 2002); for metals, some older AWQC were also selected that had been agreed upon with the agencies as appropriate for the site and used during the five-year review (TtEMI 2002a). For soil and sediment, the lower of the effects range-low (ER-L) or available soil or wildlife preliminary remediation goals (PRG) were used (Long and Morgan 1990; Long and others 1995; Efroymson and others 1997a and b).

Appendix D Tables D-1 through D-3 compare the PRRLs for the selected standard analytical methods for aqueous and bulk media with relevant criteria or toxicological benchmarks for water and soil. These comparisons show that the selected analytical methods and associated PRRLs are generally capable of quantifying contaminants of concern at or below the applicable screening values in most cases. The specific exceptions include selected analytes from each of the major groups: SVOCs, pesticides, Aroclors, and metals; however, these exceptions have been judged to be acceptable for the following reasons:

- In comparing the PRRLs to screening criteria or benchmarks, however, it is important to note that actual laboratory quantitation limits may be lower than PRRLs and that estimates of analyte concentrations down to MDLs can typically be provided in order to allow comparisons to screening levels that are below PRRLs.
- For SVOCs and pesticides, the purpose of the investigation is site characterization of unusual ashy soils in RASS 4 and the standard methods are considered adequate to identify highly contaminated soils.
- For Aroclors, the data gaps evaluation will use total Aroclor concentrations and will compare total concentrations to previously measured concentrations of 1.5 mg/kg that indicated little or no risk; the standard methods are considered adequate to perform this evaluation.
- For metals, the standard methods have been used for previous investigations; the newly collected data will primarily be compared to previously measured concentrations rather than to screening values so the standard methods are considered adequate.

For this project, samples analyzed for PCBs, SVOCs, and metals will be reported as estimated values if concentrations are less than PRRLs but greater than MDLs. The MDL for each analyte will be listed as the detection limit in the laboratory’s electronic data deliverable (EDD). This procedure is being adopted to help ensure that analytical results can effectively be compared with screening values for certain compounds where the PRRL is near or below the screening value. This procedure also will help to ensure that subsequent statistical evaluations of the data will not be biased by high-value nondetect results. It is anticipated that estimated concentrations would be used in the data analysis.

1.4 PROJECT ORGANIZATION

Table 5 presents the responsibilities and contact information for key personnel involved in field investigation activities at the NWSSDB Concord Litigation Area. In some cases, more than one responsibility has been assigned to a person. Figure 3 presents the organization of the project team.

1.5 SPECIAL TRAINING AND CERTIFICATION

This section outlines the training and certification required to complete the activities described in this SAP. The following sections describe the requirements for TtEMI and subcontractor personnel working on site.

1.5.1 Health and Safety Training

TtEMI personnel who work at hazardous waste project sites are required to meet the Occupational Safety and Health Administration (OSHA) training requirements defined in Title 29 Code of Federal Regulations (29 CFR) Part 1910.120(e). These requirements include: (1) 40 hours of formal off-site instruction; (2) a minimum of 3 days of actual on-site field experience under the supervision of a trained and experienced field supervisor; and (3) 8 hours of annual refresher training.

Field personnel who directly supervise employees engaged in hazardous waste operations also receive at least 8 additional hours of specialized supervisor training. The supervisor training covers Navy health and safety program requirements, training requirements, personal protective equipment (PPE) requirements, spill containment program, and health-hazard monitoring procedures and techniques. At least one member of every TtEMI field team will maintain current certification in the American Red Cross “Multimedia First Aid” and “Cardiopulmonary Resuscitation (CPR) Modular,” or equivalent.

Copies of TtEMI’s health and safety training records, including course completion certifications for the initial and refresher health and safety training, specialized supervisor training, and first aid and CPR training, are maintained in project files.

Before work begins at a specific hazardous waste project site, TtEMI personnel are required to undergo site-specific training that thoroughly covers the following areas:

- Names of personnel and alternates responsible for health and safety at a hazardous waste project site
- Health and safety hazards present on site

TABLE 5

KEY PERSONNEL
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Name	Organization	Role	Responsibilities	Contact Information
Stephen Tyahla	Navy	Remedial project manager (Acting)	Responsible for overall project execution and for coordination with base representatives, regulatory agencies, and Navy management Actively participates in DQO process Provides management and technical oversight during data collection	Naval Facilities Engineering Command, Engineering Field Activity West (EFA-West), Daly City, CA tyahlasf@efawest.navfac.navy.mil (650) 746-7451
Narciso A. Ancog	Navy	QA officer	Responsible for QA issues for all SWDIV environmental work Provides government oversight of TtEMI's QA program Reviews and approves SAP and any significant modifications Has authority to suspend project activities if Navy quality requirements are not met	Naval Facilities Engineering Command, SWDIV, San Diego, CA ancogna@efdsw.navfac.navy.mil (619) 532-2540
Joanna Canepa	TtEMI	Installation coordinator	Responsible for ensuring that all TtEMI activities at this installation are carried out in accordance with current Navy requirements and Tetra Tech program guidance	Tetra Tech EMI, San Francisco, CA Joanna.Canepa@ttemi.com (415) 222-8362
Mary Gleason	TtEMI	Project Manager	Responsible for implementing all activities called out in DO Prepares or supervises preparation of SAP Monitors and directs field activities to ensure compliance with SAP requirements Oversees data analysis, interpretation, and report preparation	Tetra Tech EMI, San Francisco, CA Mary.Gleason@ttemi.com (415) 222-8319

TABLE 5 (Continued)

KEY PERSONNEL
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Name	Organization	Role	Responsibilities	Contact Information
Greg Swanson	TtEMI	Program QA manager	Responsible for regular discussion and resolution of QA issues with Navy QA officer Provides program-level QA guidance to installation coordinator, project manager, and project teams Reviews and approves SAPs Identifies nonconformances through audits and other QA review activities and recommends corrective action	Tetra Tech EMI, San Diego, CA Greg.Swanson@TtEMI.com (619) 525-7188
Ron Ohta	TtEMI	Project QA officer	Responsible for providing guidance to project teams that are preparing SAPs Verifies that data collection methods specified in SAP comply with Navy and TtEMI requirements May conduct laboratory evaluations and audits	Tetra Tech EMI, Sacramento, CA Ron.Ohta@TtEMI.com (916) 853-4506
Richard Vernimen	TtEMI	Field team leader	Responsible for directing day-to-day field activities conducted by TtEMI and subcontractor personnel Verifies that field sampling and measurement procedures follow SAP Provides project manager with regular reports on status of field activities	Tetra Tech EMI, San Francisco, CA Richard.Vernimen@ttemi.com (415) 222-8226
To be determined	TtEMI	On-site safety officer	Responsible for implementing health and safety plan and for determining appropriate site control measures and personal protection levels Conducts safety briefings for TtEMI and subcontractor personnel and site visitors Can suspend operations that threaten health and safety	To be determined

TABLE 5 (Continued)

KEY PERSONNEL
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

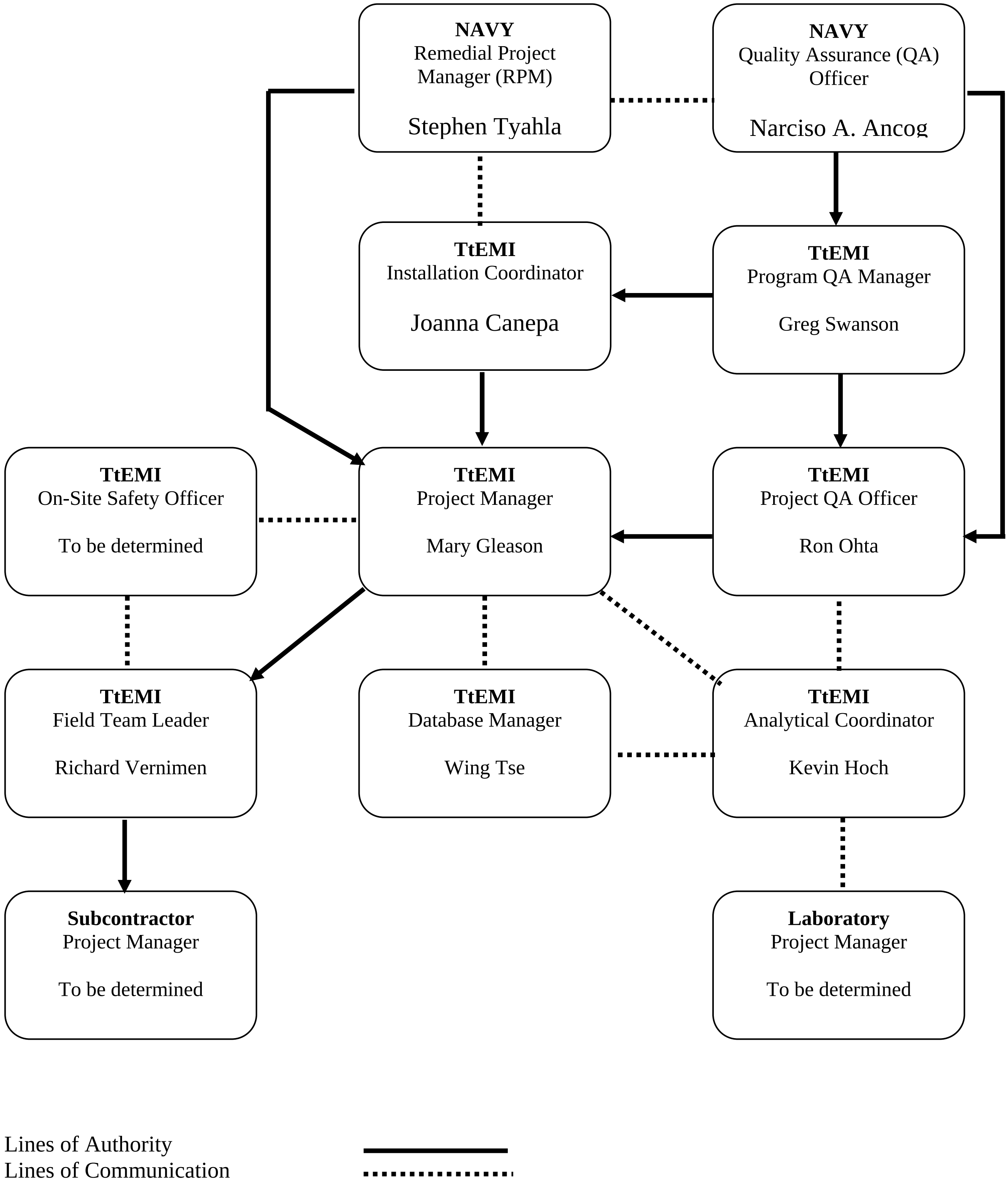
Name	Organization	Role	Responsibilities	Contact Information
Kevin Hoch	TtEMI	Chemist	Responsible for working with project team to define analytical requirements Assists in selecting a pre-qualified laboratory to complete required analyses (see Section 2.4 of SAP) Coordinates with laboratory project manager on analytical requirements, delivery schedules, and logistics Reviews laboratory data before they are released to project team	Tetra Tech EMI, San Francisco, CA Kevin.Hoch@TtEMI.com (415) 222-8304
Wing Tse	TtEMI	Database manager	Responsible for developing, monitoring, and maintaining project database under guidance of project manager Works with analytical coordinator during preparation of SAP to resolve sample identification issues	Tetra Tech EMI, San Francisco, CA Wing.Tse@TtEMI.com (415) 222-8326
To be determined	Laboratory	Project manager	Responsible for delivering analytical services that meet requirements of SAP Reviews SAP to understand analytical requirements Works with TtEMI analytical coordinator to confirm sample delivery schedules Reviews laboratory data package before it is delivered to Tetra Tech	To be determined
To be determined	Subcontractor	Project manager	Responsible for ensuring that subcontractor activities are conducted in accordance with requirements of SAP Coordinates subcontractor activities with TtEMI project manager or field team leader	To be determined

Notes:

DQO Data quality objective
Navy U.S. Department of the Navy
QA Quality assurance
RPM Remedial project manager
SAP Sampling and analysis plan
SWDIV Naval Facilities Engineering Command, Southwest Division
TtEMI Tetra Tech EM Inc.

FIGURE 3

PROJECT TEAM ORGANIZATION CHART



- Selection of the appropriate personal protection levels
- Correct use of PPE
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment on site
- Medical surveillance requirements, including recognition of symptoms and signs that might indicate overexposure to hazardous substances
- Contents of the basewide health and safety plan (HSP) (TtEMI 1998)

1.5.2 Subcontractor Training

Subcontractors who work on site will certify that their employees have been trained for work on hazardous waste project sites. Training will meet OSHA requirements defined in 29 CFR 1910.120(e). Before work begins at the project site, subcontractors will submit copies of the training certification for each employee to TtEMI.

All employees of associate and professional services firms and technical services subcontractors will attend a safety briefing and complete the "Safety Meeting Sign-Off Sheet" before conducting on-site work. This briefing covers the topics described in Section 1.5.1 and is conducted by the TtEMI on-site health and safety coordinator (OHSC) or other qualified person.

Subcontractors are responsible for conducting their own safety briefings. TtEMI personnel may audit these briefings.

1.6 DOCUMENTS AND RECORDS

Documentation is critical for evaluating the success of any environmental data collection activity. The following sections discuss the requirements for documenting field activities and for preparing laboratory data packages. This section also describes reports that will be generated as a result of this project.

1.6.1 Field Documentation

Complete and accurate documentation is essential to demonstrate that field measurement and sampling procedures are carried out as described in the SAP. Field personnel will use permanently bound field logbooks with sequentially numbered pages to record and document field activities. The logbook will list the contract name and number, the DO number, the site name, and the names of subcontractors, the service client, and the project manager. At a minimum, the following information will be recorded in the field logbook:

- Name and affiliation of all on-site personnel or visitors
- Weather conditions during the field activity
- Summary of daily activities and significant events
- Notes of conversations with coordinating officials
- References to other field logbooks or forms that contain specific information
- Discussions of problems encountered and their resolution
- Discussions of deviations from the SAP or other governing documents
- Description of all photographs taken

The field team will also use the various field forms included in Appendix C to record field activities.

1.6.2 Summary Data Package

The subcontracted laboratory will prepare summary data packages in accordance with the instructions provided in the EPA Contract Laboratory Program (CLP) statements of work (SOW) (EPA 1999a, 2000e). The summary data package will consist of a case narrative, copies of all associated chain-of-custody (COC) forms, sample results, and quality assurance and quality control (QA/QC) summaries. The case narrative will include the following information:

- Subcontractor name, project name, DO number, project order number, sample delivery group (SDG) number, and a table that cross-references client and laboratory sample identification (ID) numbers
- Detailed documentation of all sample shipping and receiving, preparation, analytical, and quality deficiencies
- Thorough explanation of all instances of manual integration
- Copies of all associated nonconformance and corrective action forms that will describe the nature of the deficiency and the corrective action taken
- Copies of all associated sample receipt notices

Additional summary data package requirements are outlined in Table 6. The subcontracting laboratory will provide TtEMI with two copies of the summary data package within 28 days after they receive the last sample in the SDG.

1.6.3 Full Data Package

When a full data package is required, the laboratory and soil gas subcontractors will prepare data packages in accordance with the instructions provided in the EPA CLP statements of work (EPA 1999a, 2000e). Full data packages will contain all of the information from the summary data package and all associated raw data. Full data package requirements are outlined in Table 6. Full data packages are due to TtEMI within 35 days after the last sample in the SDG is received. Unless otherwise requested, the subcontractor will deliver one copy of the full data package.

1.6.4 Data Package Format

The subcontracted laboratory will provide EDDs for all analytical results. An automated laboratory information management system (LIMS) must be used to produce the EDDs. Manual creation of the deliverable (data entry by hand) is unacceptable. The laboratory will verify EDDs internally before they are issued. The EDDs will correspond exactly to the hard-copy data. No duplicate data will be submitted. EDDs will be delivered in a format compatible with Navy Electronic Data Deliverable (NEDD). Results that should be included in all EDDs are as follows:

- Target analyte results for each sample and associated analytical methods requested on the COC form
- Method and instrument blanks and preparation and calibration blank results reported for the SDG
- Percent recoveries for the spike compounds in the MS, MSDs, blank spikes, or LCSs
- Matrix duplicate results reported for the SDG
- All re-analysis, re-extractions, or dilutions reported for the SDG, including those associated with samples and the specified laboratory QC samples

Electronic and hard copy data must be retained for a minimum of 3 and 10 years, respectively, after final data have been submitted. The subcontractor will use an electronic storage device capable of recording data for long-term, off-line storage. Raw data will be retained on an electronic data archival system.

1.6.5 Reports Generated

TER will be prepared to present an evaluation and summary of the new data collected for RASS 1, 2, 3, and 4. The goal of the TER is to assist the Navy in identifying potential off-site sources of contamination and evaluating potential actions for the site. The TER will present an evaluation of whether metals or pH could be causing the area of distressed vegetation in RASS 1, the groundwater-surface water interactions at the border of CPC, current metals contamination in groundwater in existing and new wells, the presence and potential ecological risk of Aroclors in RASS 3 soils, and the chemical concentrations ashy soils in RASS 4.

TABLE 6

REQUIREMENTS FOR SUMMARY AND FULL DATA PACKAGES

Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Requirements for Summary Data Packages – Organic Analysis	Requirements for Summary Data Packages – Inorganic Analysis
Section I **Case Narrative**	**Section I** **Case Narrative**
1. Case narrative	1. Case narrative
2. Copies of nonconformance and corrective action forms	2. Copies of nonconformance and corrective action forms
3. Chain-of-custody forms	3. Chain-of-custody forms
4. Copies of sample receipt notices	4. Copies of sample receipt notices
5. Internal tracking documents, as applicable	5. Internal tracking documents, as applicable
Section II **Sample Results - Form I for the following:**	**Section II** **Sample Results - Form I for the following:**
1. Environmental samples, including dilutions and re-analysis	1. Environmental sample including dilutions and re-analysis
2. Tentatively identified compounds (TIC) (SVOC only)	
	Section III **QA/QC Summaries - Forms II through XIV for the following:**
Section III **QA/QC Summaries - Forms II through XI for the following:**	1. Initial and continuing calibration verifications (Form II)
1. System monitoring compound and surrogate recoveries (Form II)	2. PRRL standard (Form II)
2. MS and MSD recoveries and RPDs (Forms I and III)	3. Detection limit standard (Form II-Z)
3. Blank spike or LCS recoveries (Forms I and III-Z)	4. Method blanks, continuing calibration blanks, and preparation blanks (Form III)
4. Method blanks (Forms I and IV)	5. Inductively coupled plasma (ICP) interference-check samples (Form IV)
5. Performance check (Form V)	6. MS and post-digestion spikes (Forms V and V-Z)
6. Initial calibrations with retention time information (Form VI)	7. Sample duplicates (Form VI)
7. Continuing calibrations with retention time information (Form VII)	8. LCSs (Form VII)
8. Quantitation limit standard (Form VII-Z)	9. Method of standard additions (Form VIII)
9. Internal standard areas and retention times (Form VIII)	10. ICP serial dilution (Form IX)
10. Analytical sequence (Forms VIII-D and VIII-Z)	11. IDL (Form X)
11. Gel permeation chromatography (GPC) calibration (Form IX)	12. ICP interelement correction factors (Form XI)
12. Single component analyte identification (Form X)	13. ICP linear working range (Form XII)
13. Multicomponent analyte identification (Form X-Z)	
14. Matrix-specific MDL (Form XI-Z)	

TABLE 6 (Continued)

REQUIREMENTS FOR SUMMARY AND FULL DATA PACKAGES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Requirements for Full Data Packages -- Organic Analysis	Requirements for Full Data Packages -- Inorganic Analysis
Sections I, II, and III **Summary Package**	**Sections I, II, III** **Summary Package**
Section IV **Sample Raw Data - indicated form, plus all raw data**	**Section IV** **Instrument Raw Data - Sequential measurement readout records for ICP, graphite furnace atomic absorption (GFAA), flame atomic absorption (AA), cold vapor mercury, cyanide, and other inorganic analyses, which will contain the following information:**
1. Analytical results, including dilutions and re-analysis (Forms I and X)	1. Environmental samples, including dilutions and re-analysis
2. TICs (Form I — VOA and SVOA only)	2. Initial calibration
	3. Initial and continuing calibration verifications
Section V **QC Raw Data - indicated form, plus all raw data**	4. Detection limit standards
1. Method blanks (Form I)	5. Method blanks, continuing calibration blanks, and preparation blanks
2. MS and MSD samples (Form I)	6. ICP interference check samples
3. Blank spikes or LCSs (Form I)	7. MS and post-digestion spikes
	8. Sample duplicates
Section VI **Standard Raw Data - indicated form, plus all raw data**	9. LCSs
1. Performance check (Form V)	10. Method of standard additions
2. Initial calibrations, with retention-time information (Form VI)	11. ICP serial dilution
3. Continuing calibrations, with retention-time information (Form VII)	
4. Quantitation-limit standard (Form VII-Z)	**Section V** **Other Raw Data**
5. GPC calibration (Form IX)	1. Percent moisture for soil samples
	2. Sample digestion, distillation, and preparation logs, as necessary
Section VII **Other Raw Data**	3. Instrument analysis log for each instrument used
1. Percent moisture for soil samples 2. Sample extraction and cleanup logs	4. Standard preparation logs, including initial and final concentrations for each standard used
3. Instrument analysis log for each instrument used (Form VIII-Z)	5. Formula and a sample calculation for the initial calibration
4. Standard preparation logs, including initial and final concentrations for each standard used	6. Formula and a sample calculation for soil sample results
5. Formula and a sample calculation for the initial calibration	
6. Formula and a sample calculation for soil sample results	

2.0 DATA GENERATION AND ACQUISITION

This section describes the requirements for the following:

- Sampling Process Design (Section 2.1)
- Sampling Methods (Section 2.2.)
- Sample Handling and Custody (Section 2.3)
- Analytical Methods (Section 2.4)
- Quality Control (Section 2.5)
- Equipment Testing, Inspection, and Maintenance (Section 2.6)
- Instrument Calibration and Frequency (Section 2.7)
- Inspection and Acceptance of Supplies and Consumables (Section 2.8)
- Non-direct Measurements (Section 2.9)
- Data Management (Section 2.10)

2.1 SAMPLING PROCESS DESIGN

This section describes the sampling process design for the Litigation Area data gaps evaluation. Each data gaps to be evaluated in the RASSs are discussed in the following sections. Information on surveying sampling locations and locating underground utilities is also presented below.

The number of samples, sample types, analytes, and sampling rationale for the data gaps evaluation is summarized by RASS in Table 7. Table 7 includes samples collected for quality control purposes and to characterize investigation-derived waste (IDW). Proposed sample locations are shown on Figure 2.

2.1.1 Distressed Vegetation Area in RASS 1

To investigate the cause of distressed vegetation observed adjacent to the earthen berm between GCC property and Navy property, the Navy will collect soil samples from two depths (0 to 0.5 feet and 1 to 1.5 feet bgs) at 12 locations and will collect grab groundwater samples from nine of these locations. Sampling locations include a line of samples parallel to the berm and three transects perpendicular to the berm (Figure 2). The soil samples will be analyzed for total metals, pH, and TOC. The grab groundwater samples will be analyzed for dissolved metals and pH.

TABLE 7

SUMMARY OF PROPOSED SAMPLES, ANALYSES, AND RATIONALE

Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Type of Samples	Analytes	Matrix	Number of Sampling Locations	Field Duplicate Samples	Equipment Rinsate Samples	Total Number of Samples	Rationale
RASS 1 Soil Samples	Metals pH	Soil	24 24	0 0	1 1	25 25	Metals and pH need to be characterized in area of distressed vegetation
RASS 3 Soil Samples	Aroclors (PCBs)	Soil	16	0	1	17	Aroclors not fully characterized along railroad track in RASS 3
RASS 4 Soil Samples	Metals SVOCs Pesticide/PCB TOC pH	Soil	3 3 3 3 3	0 0 0 0 0	1 1 1 1 1	4 4 4 4 4	Observation of unusual ashy or semi-lithified soils; chemistry needs to be characterized
RASS 1 Grab Groundwater Samples	Filtered Metals pH	Water	9 9	1 1	1 1	11 11	Metals and pH need to be characterized in area of distressed vegetation
RASS 1, 2, and 3 Groundwater Samples from Wells	Total Metals TSS pH	Water	18 18 18	2 2 2	1 1 1	21 21 21	Groundwater has not been investigated since 1996
IDW Samples	Metals Metals Pesticides/PCBs SVOCs	Soil Water Soil Water	NA	NA	NA	1 1 1 1	Required for proper disposal

Notes: It is assumed that one composite sample from one drum of soils and one composite water sample will be sufficient to characterize and dispose of the investigation-derived waste generated during this investigation.

This table presents the number of samples to be collected. It includes the investigation-derived waste samples to be collected for waste characterization.

One source water blank will be collected from the source of water used for the final decontamination rinse. This sample will be analyzed for all of the project analytes.

Matrix spike and matrix spike duplicates are not considered additional samples. Metals will include waste extraction test for analysis of investigation-derived waste soils.

NA Not applicable
QC Quality control
IDW Investigation-derived waste
PCB Polychlorinated biphenyls
pH Hydrogen
SVOC Semivolatile organic compound
TOC Total organic carbon
TSS Total suspended solids

2.1.2 Groundwater-Surface Water Interactions at Chemical and Pigment Company Border

Groundwater-surface water interaction near the northwest corner of CPC property will be investigated in order to assess the possibility that discharge of contaminated groundwater from CPC property is affecting water quality in Nichols Creek. A shallow perched zone beneath CPC property reported in the Hydrogeologic Assessment Report (HAR) (Environmental Solutions 1987) is of particular interest because high concentrations of zinc were reported in groundwater from this zone, and because the perched zone may offer a direct preferential flow pathway that allows discharge of contaminated groundwater to Nichols Creek. To investigate this possibility, the Navy will install a new monitoring well near the northwest corner of CPC property, install a staff gage in Nichols Creek to allow monitoring creek water elevation, and perform a detailed water elevation survey of selected Navy wells, CPC wells, and surface water in Nichols Creek.

The staff gage in Nichols Creek will be permanently attached to an immobile fixture such as a metal surveying stake, which will be driven at least 18 inches into the creek bed. The staff gage will be placed in a location near the deepest part of the creek bed, but away from the center of the creek and at least 25 feet south of the land bridge that crosses Nichols Creek near the northwest corner of CPC. The area near the land bridge periodically fills with driftwood during storms, which could damage the staff gage.

After the new monitoring well is installed, the Navy will conduct a water level survey and will measure the water levels in the newly installed monitoring well; Navy wells 3MG06, 3MG11, 3MG12, 3MH13, 3MG14, and 3MG19 (Figure 2); and selected CPC monitoring wells, chosen based on review of lithologic logs. Selected CPC wells will include at least three wells screened across the perched zone and at least three wells screened in the deeper aquifer, if possible. The Navy has received verbal permission from DTSC to access the site to conduct the required measurements in CPC wells, provided DTSC staff is present.

Measuring water levels in the CPC wells will require access to CPC property, removal of locking well caps and obstructions within the monitoring wells that could prevent accurate water level measurement, and pumping records to assess possible pumping effects on potentiometric surfaces (if the wells are pumped). The condition of groundwater wells at CPC is not known; DTSC staff has indicated that wells have not been maintained since 1998 and may need some development before sampling can be conducted. Water level in Nichols Creek will be measured to the nearest 0.05 feet by visually recording the water level on the staff gage. Nichols Creek may not contain running water in late August; in this case, the surface water level will be assumed to be less than the lowest elevation in the creek bed.

2.1.3 Litigation Area Groundwater Well Sampling

A subset of the Litigation Area monitoring wells will be sampled during August 2003 to assess current groundwater quality in the Litigation Area. The Litigation Area wells were last sampled in October 1996. At that time, all of the wells were inspected and upgraded as necessary to comply with California well standards for monitoring wells (Department of Water Resources [DWR] 1981, 1991). During the proposed work, any deficiencies or variations from the standards will be noted, and slated for correction as part of future work.

Monitoring wells have been sampled repeatedly for organic contaminants, yet no significant contamination of groundwater by these contaminants has been detected (TtEMI 1997). Accordingly, the wells will be sampled for total metals, total suspended solids (TSS), and pH in 2003. Sampling will be performed during a period when high tides do not flood the marsh surface, if possible. National Oceanic and Atmospheric Administration [NOAA] tidal predictions indicate that the period between August 15 and August 22, 2003 will correspond with low tidal amplitudes.

In 1996, 11 of the 22 monitoring wells in the Litigation Area were sampled. In 2003, 18 of the monitoring wells will be sampled, including a new well to be installed near the northwest corner of CPC property. Wells to be sampled and the rationale for selecting these wells is presented in Table 8.

The tidal influence study (TtEMI 1997) showed that although water levels in some monitoring wells responded to tidal variations in Suisun Bay, electrical conductivity of groundwater in the same wells remained essentially constant, indicating that water quality does not vary significantly with the tides. As a result, there does not appear to be a need to time the sampling of the wells to coincide with a particular portion of the tidal cycle.

2.1.4 RASS 3 Polychlorinated Biphenyl Sampling

Additional sampling and characterization of PCB concentrations is needed for areas along the SPTC railroad tracks, in areas of RASS 3 where previous sampling revealed elevated concentrations, and at several locations along Nichols Creek between the CPC and SPTC property (Figure 2).

TABLE 8

SUMMARY OF GROUNDWATER WELLS PROPOSED TO BE SAMPLED
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Monitoring Well	Rationale for Sampling
1AG02 1AG04 1PG05 1PG18 2MG07 2AG09 3AG10 3MG11 3MG12 4MG15 4MG16	Sampled in 1996; provides good lateral distribution of sampling points across Litigation Area and allows for comparison of current and past conditions
New monitoring well near CPC	Not previously sampled, evaluate groundwater contamination from upgradient source
3MG13 3MG14 3MG06	Located near potential upgradient contaminant source
1MG01	Closest to Suisun Bay
1AG03	Downgradient from distressed vegetation area
2AG08	Monitor zinc concentrations, which have been elevated in this well in the past

As described in Section 1.2.2, a total of 16 soil samples will be collected for analysis of seven Aroclors (PCB mixtures). Six surface (0 to 0.5 feet bgs) samples will be collected along a corridor adjacent to the SPTC railroad tracks, but on Navy property. Sampling will employ a random starting position for the first sample, and subsequent samples will be collected at approximately equal distances from one another along an 1,800-foot transect parallel to the railroad tracks. Two surface samples will be collected along Nichols Creek at staggered locations between the border of the CPC property and the railroad tracks. Four surface (0 to 0.5 feet bgs) and four subsurface (1 to 1.5 feet bgs) soil samples will be collected from a triangular array (one location at each of the corners and one location in the center of the triangle), centered on location R03SS214 (Figure 2, RASS 3 inset), where elevated concentrations of PCBs were previously measured.

2.1.5 RASS 4 Semi-lithified Soil Sampling

The unusual nature of semi-lithified soil observed in RASS 4, raised questions about its source and chemical composition. Additional sampling of this area of semi-lithified soil is needed to fully characterize the chemical composition of this material. Three surface (0 to 0.5 feet bgs) soil samples will be collected along the motorcycle tracks near the remediated portion of RASS 4 where areas of semi-lithified materials have been observed. The samples will be analyzed for total metals, SVOCs, Aroclors, pesticides, TOC, and pH.

2.1.6 Surveying

Several of the data generation activities discussed above will require surveying to establish horizontal and vertical coordinates of sampling points or measurement locations. Horizontal locations of the soil and grab groundwater samples will be established with GPS equipment. Because NWS SBD Concord is located in a coastal area, real time differential corrections are possible, which will allow accurate determination of horizontal locations with greater accuracy than in areas where differential corrections are not feasible.

Groundwater and surface water elevations will be essential to evaluate groundwater-surface water interactions in the area at the northwest corner of the CPC property. Groundwater, surface water, and ground surface elevations from Navy property and CPC property must be brought into a common reference system to allow accurate evaluation of lithologic and potentiometric relationships. Surveying in this area will have three objectives:

(1) Establish elevations of water level measuring points for the CPC monitoring wells relative to a known benchmark. Survey information for CPC wells is of unknown quality and measured relative to an unknown datum; the top of inner casing points for the CPC monitoring wells must be established relative to the same vertical datum as the Litigation Area monitoring wells and Nichols Creek.

(2) Establish surface water and creekbed elevations in Nichols Creek at the same time as the groundwater elevations in nearby CPC and Litigation Area wells. This objective will be accomplished by surveying horizontal and vertical coordinates of a fixed elevation on a staff gage in Nichols Creek, to allow conversion of staff gage measurements to absolute elevations.

(3) Establish ground surface elevations for CPC wells to allow detailed lithologic correlation. Lithologic logs for the CPC borings are constructed relative to ground surface and referenced to an unknown benchmark. Referencing lithologic logs to a common benchmark will ensure that elevations of geologic contacts can be established with sufficient accuracy to evaluate elevation of lithologic units on CPC property relative to those on Navy property and the bottom of Nichols Creek.

To accomplish these objectives, a professional land surveyor, licensed in the State of California will survey the following locations:

- The ground surface and top of inner casing of a subset of CPC wells: Exact wells to be surveyed will be determined based on review of lithologic logs for the CPC wells.

- A reference point on the staff gage established in Nichols Creek near the northwest corner of CPC property.
- The deepest spot at the bottom of Nichols Creek near the northwest corner of CPC property.
- The ground surface and top of inner casing of the newly installed Navy well at the northwest corner of CPC property.

To ensure a common reference system, the proposed surveying will be tied in to the same U.S. Geological Survey (USGS) benchmark used for previous surveying. The benchmark that was used previously is located at the bridge over the railroad tracks on Nichols Road (USGS Benchmark FX-1, easting 1571805.95, northing 566064.52, elevation 33.76). All horizontal elevations will be shall be established to an accuracy of 0.1 foot and referenced to California State Plane Coordinate System, Zone 3, North American Datum 1927. Top of casing and all other vertical elevations shall be shall be established to an accuracy of 0.01 foot and referenced to the National Geodetic Vertical Datum of 1929.

2.1.7 Underground Utility Survey

An underground utilities locator will clear the new groundwater monitoring well location before any intrusive activities begin. The survey will include several underground utility lines that could potentially be in the area, such as, water distribution piping, telecommunications, storm sewer, sanitary sewer, industrial wastewater, gasoline, and electrical lines.

An underground utility survey will not be required at the other RASS locations since sampling will be conducted using hand tools at depths not exceeding 3.0 feet bgs.

2.2 SAMPLING METHODS

This section describes the procedures for sample collection, including sampling methods and equipment, monitoring well installation, sample preservation requirements, decontamination procedures, and management of investigation derived waste.

2.2.1 Sampling Methods and Equipment

Sampling methods and equipment for collecting surface and near-surface soil samples and grab groundwater samples are described in Sections 2.2.1.1 and 2.2.1.2, respectively. Groundwater monitoring well installation and development, borehole lithologic logging, water level measurement, and groundwater sample collection from monitoring wells is described in Sections 2.2.1.3 through 2.2.1.6.

2.2.1.1 Surface and Near-Surface Soil Sampling

Surface (0 to 0.5 feet bgs) and near-surface (1 to 1.5 feet bgs) will be collected at the locations shown on Figure 2. Equipment used to collect these samples may include a combination of hand auger, shovel, trowels, and stainless steel spoons.

Stainless steel trowels and spoons will be used to collect soil samples from 0 to 0.5 feet bgs. Clean trowels will be used to excavate surface soil samples and place them in a clean stainless steel bowl for homogenization and then into the appropriate sampler container. Table 9 lists the appropriate sample containers for the respective project analyses.

Near-surface soil samples will be collected using a hand auger and stainless steel trowels or spoons. The hand auger is rotated directly into the soil at an angle of 90 degrees from horizontal. When the entire auger blade has penetrated soil, the auger is removed by lifting it straight up without turning it, if possible. If the desired sampling depth has not been reached, the soil is removed from the auger and deposited on plastic sheeting. This procedure is repeated until the desired depth is reached and the soil sample is obtained. The auger is then removed from the boring and the soil sample is placed in a stainless steel bowl and the sample is homogenized with a stainless steel spoon. A stainless steel trowel or spoon may also be used to transfer the soil sample from the bowl to the sample container.

Soil sample borings will be back-filled with soil from the respective sampling location.

All hand augers, trowels, spoons and other re-usable equipment that may come in contact with soil samples will be decontaminated prior to its first use and in between the collection of discreet soil samples. The decontamination procedures described in Section 2.2.2 will be followed. In general, equipment decontamination will follow these four steps: (1) Scrubbing with a nylon-bristle brush and with laboratory-grade nonphosphate detergent, (2) Rinsing with tap water, (3) Rinsing with deionized water, and (4) Air drying and wrapping in clean plastic.

2.2.1.2 Groundwater Grab Sample Collection

Grab groundwater samples will be collected in the RASS 1 distressed vegetation area from a subset of the locations where soil samples are collected (Figure 2). At each sampling location, a shallow borehole will be advanced using a hand auger. A shovel and trowel may also be used to aid in excavating the boreholes. The boreholes will be advanced deep enough to penetrate the shallow groundwater saturation zone. This zone is estimated to begin at approximately 2 to 3 feet bgs. Depth to water will be estimated by observing saturation of the soils.

TABLE 9

SAMPLE CONTAINER, HOLDING TIME, AND PRESERVATIVE REQUIREMENTS

Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Parameter	Method Number	Sample Volume	Sample Container	Preservative	Holding Time[a]
Soil					
Metals (except Mercury)	EPA 6010B/SW-846	2.5 grams	One 16-ounce glass jar with Teflon-lined cap	Cool 4 ± 2ºC	180 days
Mercury	EPA 7471A/SW-846	0.2 gram	A subsample from the container for metals analysis	Cool 4 ± 2ºC	28 days
Pesticides	EPA 8081A/SW-846	30 grams	One 8-ounce glass jar with Teflon-lined cap	Cool 4 ± 2ºC	14 days/40 days
PCBs	EPA 8082/SW-846	30 grams	A subsample from the container for pesticide analysis	Cool 4 ± 2ºC	14 days/40 days
SVOC	EPA 8270C/SW-846	30 grams	A subsample from the container for pesticide analysis	Cool 4 ± 2ºC	14 days/40 days
pH	EPA 9040/9045A, SW-846	250-mL Jar	A subsample from the container for metals analysis	Cool 4 ± 2ºC	2 days
Water					
Metals (except Mercury)	EPA 6010B/SW-846	1 Liter	Polyethylene	pH < 2 with HNO_3; Cool 4 ± 2ºC	6 months
Mercury	EPA 7470A/SW-846	100 mL	A subsample from the container for metals analysis	pH < 2 with HNO_3; Cool 4 ± 2ºC	28 days
SVOC	EPA 8270C, SW-846	Two 1-L bottles	Amber glass with Teflon-lined lid	Cool 4 ± 2ºC	7 days/40 days
Pesticides	EPA 8081A/SW-846	Two 1-L bottles	Amber glass with Teflon-lined lid	Cool 4 ± 2ºC	7 days/40 days
PCBs	EPA 8082/SW-846	Two 1-L bottles	Amber glass with Teflon-lined lid	Cool 4 ± 2ºC	7 days/40 days

TABLE 9 (Continued)

SAMPLE CONTAINER, HOLDING TIME, AND PRESERVATIVE REQUIREMENTS
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Notes:	More than one analysis can be performed from the same sample container. The sample quantities listed in the table are the quantities necessary if only the specific analysis is requested. The laboratory will indicate which of the analyses can be performed from the same container so that a smaller quantity of sample can be collected at each depth.
	Additional sample volume will be collected at 5% of the groundwater sampling locations for matrix spike / matrix spike duplicate analysis.
	Analyses for characterization of investigation-derived waste (IDW) samples are included in the table.
a	"x" days/"y" days refers to the maximum number of days from sampling to extraction/the maximum number of days from extraction to analysis.

EPA	U.S. Environmental Protection Agency
HNO_3	Nitric acid
L	Liter
mL	Milliliter
PCB	Polychlorinated biphenyl
SVOC	Semivolatile organic compound

Any water that seeps into the borehole when the boring is advanced will be evacuated with a peristaltic pump. The borehole will then be allowed to recharge naturally until a sufficient volume (approximately 1.5 liters) for a metals and pH sample seeps into the borehole. The groundwater present in the boreholes will be collected with a peristaltic pump equipped with disposable polyethylene and silicone tubing. Water will be pumped directly from the borings, through a 0.45-micron in-line filter into metals sample bottles preserved with nitric acid. The filter will be disconnected from the pump, and a pH sample will be collected.

Because of the slow expected groundwater recharge rate at the sample pits, it may be necessary to allow the pits to fill overnight and return the following day to collect samples. To avoid tidewater that could flow into the grab groundwater pits during a 24-hour tidal cycle, the sampling will be carried out on a day when the tidal cycle will not produce tidewater flows that may reach the sampling area.

The grab groundwater borings will be backfilled with native material. Equipment used to excavate the pits will be decontaminated between sampling locations using the procedure described in Section 2.2.2.

Sample locations will be marked with a wooden stake pounded into the ground adjacent to the boring. Each stake will be labeled with a unique location identification number to facilitate documenting sample locations with global positioning system (GPS) equipment.

2.2.1.3 Groundwater Monitoring Well Installation and Development

The new groundwater monitoring well will be installed on Navy property in RASS 3 near the northwestern border of CPC. Detailed lithologic logging of the well boring will be performed and the well will be developed in preparation for collecting groundwater samples. The well will be installed according to the procedures specified in TtEMI Standard Operating Procedure (SOP) 20, “Monitoring Well Installation” (Appendix B).

A brief description of the procedure for monitoring well installation is outlined in the following text. The monitoring well boring will be installed with 8-1/4-inch, steel, hollow-stem augers. Split-spoon samples for lithologic logging will be collected continuously from the surface to the total depth of the boring, and a detailed lithologic log of each boring will be prepared by the field geologist (general procedures for lithologic logging are described in Section 2.2.1.4). The well will be constructed of 2-inch-diameter, schedule-40 polyvinyl chloride (PVC) pipe. The well screen will be 10-feet long, 2-inch-diameter, schedule 40 PVC with 0.010-inch slot-size to allow suitable recharge in low-permeability formations and to allow seasonal water table fluctuations. The well screen will intersect the water table, and the top of the well screen will be set at 2 feet above the water table. A shorter, 5-foot long well screen may be used if a thin (2 to 5 feet thick) seam of sand is identified during borehole lithology logging. The filter pack will consist of coarsely graded sand that will be installed by pouring from the surface through the interval from 1 foot above and to 1 foot below the well screen. The sand will be poured slowly, and level of the sand will be periodically tested with a weighted steel tape to prevent bridging. A 2-foot-thick impermeable seal consisting of bentonite pellets, will be installed at the top of the filter pack, and the annular space from the top of the bentonite seal to the surface will be filled with cement-bentonite grout, emplaced with a tremmie pipe from the bottom of the open annular space to the surface. The monitoring well's surface completion will consist of a concrete pad with a steel outer protective casing that rises approximately 2 feet above grade to protect the PVC well casing. The well will be secured with a padlock.

Well development is generally conducted as an integral step of monitoring well installation to remove the finer-grained material, clay and silt, from the geologic formation near the well screen and filter pack. The new groundwater monitoring well in RASS 3 will be developed according to the mechanical surging technique specified in TtEMI SOP 21, "Monitoring Well Development" (Appendix B). This mechanical surging technique is briefly described in the following text.

The well will be swabbed progressively from top to bottom with a surge block a minimum of two times to agitate sediment within the casing, remove fines from the sand pack, and seat the sand pack firmly in place. Each time the well is swabbed, the surge block will be gently raised and lowered inside the casing below the water table for a minimum of 10 minutes or 40 strokes. This action will create flow reversals through the screen slots and agitate the fine-grained materials within the well and the sand pack. After surging has been completed, at least 3 well volumes of groundwater will be bailed (when possible) from each location to remove the fines that were agitated into suspension during surging and to ensure that groundwater entering the well will be representative of groundwater in the aquifer. The bailed water will be monitored with a water quality meter for physical parameters, including temperature, conductivity, pH, turbidity, and dissolved oxygen.

Purged well water will collected on-site in 55-gallon drums and managed as investigation-derived waste according to the procedures described in Section 2.2.3.

2.2.1.4 Monitoring Well Borehole Lithologic Logging

Lithology observed during drilling will be described by the field geologist according to American Society for Testing and Materials (ASTM) Standard D 2488-90, which is based on the Unified Soil Classification System (USCS). The following information, as appropriate, will be recorded on a standard boring log form (Appendix C) at each observed change in lithology or at least every 5 feet:

- Well designation
- Well location
- Drilling and sampling methods used
- Names of field geologist and driller
- Dates and times drilling was started and completed
- Depth at which groundwater was first encountered
- Sampling depth
- Blow counts, if appropriate
- Variations in drilling rates and rig behavior
- Sample description, including sampling depth, sample color, USCS classification, estimated moisture content, and estimated relative density
- Photo-ionization detector readings
- Signature and initials of observer

2.2.1.5 Water Level Measurements

Before each groundwater monitoring well is sampled, the static water level will be measured. Water level measurements will also be taken for selected CPC wells, the proposed new monitoring well, and other Navy wells near the CPC property, during an approximately four-hour period, to determine the groundwater flow direction in this area. On the day of a measurement event, each monitoring well will be opened and uncapped to allow removal of standing water in the vault box or standpipe and to allow water levels to equilibrate before the water level measurement is recorded. If the wells are equipped with sealing well caps that prevent pressure equalization, the wells will be vented for a minimum of one hour before measuring groundwater level.

Water levels will be measured with an electrical sounder; measurements will be taken from a reference elevation point marked on the top of the well casing. Measurements will be recorded to the nearest 0.01-foot in a field logbook. To verify accuracy, two readings will be taken. If water level measurements are not within 0.01-foot of one another, an additional reading will be obtained.

The instruments used for water level measurement will be decontaminated before and after use at each well. The electric-sounder water level meter will be rinsed with distilled water and wiped off with a clean paper towel before each use.

2.2.1.6 Groundwater Sample Collection from Monitoring Wells

As described in Section 2.1.3, one round of groundwater sampling will be conducted to measure total metals, TSS, and pH in 17 existing Litigation Area wells and the new well to be installed in RASS 3 adjacent to the CPC property. Table 7 presents the proposed project samples, analyses and sample rationale. Low flow-rate purging techniques will be used, where technically feasible, to obtain groundwater samples from wells.

Studies by EPA have shown that low flow-rate purging techniques can be used to obtain more accurate and representative groundwater samples for metals analyses than conventional sampling and filtering techniques (Puls and Powell 1992). A principle objective of low flow-rate purging is to avoid entraining silt- and clay-sized particles in groundwater samples by purging wells at low velocities. Low velocity purging is intended to establish direct flow from the aquifer to the sample container at velocities and flow conditions comparable to *in situ* flow velocities. By using low flow-rate purging techniques, the sampling process more closely matches natural groundwater flow conditions and transport of suspended solids, and analytical problems and uncertainties caused by turbidity are reduced. The field procedure for low flow-rate sampling techniques is described as follows:

1. The depth to water will be measured with an electric-sounder water level meter to determine the equilibrium water level.
2. A weighted Tygon® or polyethylene tube will be gently lowered into the well to a depth of 3.5 feet below the equilibrium water level or 2 feet below the top of the well screen (whichever is greater) and secured to the outer well casing with tape or plastic ties.
3. Well purging will be initiated slowly and increased gradually to a rate of approximately 0.15 liter per minute (L/min) using a peristaltic pump. Purge water stabilization parameters, including pH, temperature, electrical conductivity, dissolved oxygen, and turbidity, will be measured at intervals of a minimum of 1 liter (L) and recorded on well sampling sheets or in field notebooks.
4. Purge water will be discharged into a graduated cylinder, and the volume of water purged will also be measured and recorded on well sampling sheets. If the water level decrease (drawdown) is 0.3 foot or greater at that pumping rate, procedures 5 and 6 will be initiated. If the water level drawdown is less than 0.3 foot at that pumping rate and the water level is stable, the rate will be increased to the maximum rate at which an unchanging water level is obtained (up to 0.25 L/min), and procedures 7 and 8 will be initiated.
5. When drawdown is more than 0.3 foot at a rate of 0.15 L/min, a modified low-flow purge protocol will be attempted. Using the modified low-flow purge protocol, the pump rate will be increased to a maximum of 1 L/min, and the water level will be drawn down to 1.5 to 3 feet from the equilibrium water level, in order to stimulate recharge.
6. The pumping rate will then be adjusted within the range of 0.1 to 0.25 L/min until the water level in the well is stable and the recharge rate matches the discharge rate. If the water level continues to decrease at a pumping rate of 0.1 L/min, low flow-rate purging will be considered technically infeasible.

7. The purge water will be considered stabilized after the collection of a minimum of eight measurements (8 L purged) and three successive measurements of each of the stabilization parameters that fall within the following ranges:

pH:	± 0.1
Electrical conductivity:	± 3 percent microSiemens per centimeter
Temperature:	± 0.5 °C
Dissolved oxygen:	± 0.2 milligram per L
Turbidity:	± 15 percent relative percent difference or three successive measurements of less than 15 nephelometric turbidity units

8. Well stabilization parameters will be expected to asymptotically approach a constant value as the purge water begins to stabilize. If well stabilization parameters are within the ranges specified previously but still appear to be approaching an asymptotic value, well purging will be continued until the purge water appears to be at equilibrium or until a maximum of 20-L has been purged from the well.

Two conditions will make the low flow-rate sampling technique described above technically infeasible: (1) inadequate recharge and (2) wells with water levels more than about 25 feet from the ground surface. The 1996 sampling event showed that about half of the wells in the Litigation Area marsh had inadequate recharge and were unable to support the minimum purging rate of 100 milliliters per minute (mL/min) recommended by Puls and Powell (1992) without dewatering the wells. If direct discharge of standing water from the well casing accounts for more than about 15 percent of the discharge from the pump when water level in the well is drawn down to 2 to 3 feet below the equilibrium water level, the well will be considered to have inadequate recharge.

In cases where recharge rates in the formation will not allow low flow-rate purging, the wells will be purged dry, allowed to recharge overnight, and sampled the following day, using techniques described below:

1. All water will be purged from the well with disposable Teflon® bailers or pumped out with a peristaltic pump. A weighted Tygon® or polyethylene tube will then be gently lowered into the well to a depth of 3.5 feet below the equilibrium water level or the middle of the well screen (whichever is greater) and secured to the outer well casing with tape or plastic ties.
2. The well will be allowed to recharge and will be sampled with a peristaltic pump (if possible) after the well has recovered to within 80 percent of the initial water level, but not later than 24 hours after purging.

Well stabilization parameters, including temperature, pH, electrical conductivity, dissolved oxygen, and turbidity, will be measured immediately before sampling and recorded on well sampling sheets or in field notebooks.

The following procedures will be followed in collecting groundwater samples from monitoring wells after purging has been completed:

1. Measuring and sampling equipment will be decontaminated before samples are collected from each location.
2. During sampling, well purging equipment will be positioned so that potential sources of VOCs, such as vehicles, gasoline engines, or fuel tanks, are downwind of the location of the well.
3. When the low flow-rate purging techniques are used or if samples can be collected with a peristaltic pump, water samples will be collected directly from the discharge of the peristaltic pump. If samples cannot be collected with a peristaltic pump, disposable bailers will be used.

Based on water levels measured in November 1996, wells 3MG06, 3MG13, 3MG14, and 4MG15 (Figure 2) may have water levels too low to pump the surface using a peristaltic pump. These wells will be purged a minimum of three well casing volumes using disposable bailers standard well purging techniques described in TtEMI SOP 010 "Groundwater Sampling" (Appendix B). However, standard purging and sampling techniques typically introduce normally immobile sediments into the samples, which results in high suspended sediment concentrations and associated elevated metals concentrations. These suspended sediments are typically removed from samples for metals analysis using in-line 0.45-micron filters. However, analytical results from filtered samples from these wells are not directly comparable with results from unfiltered samples from the other wells. To overcome this problem, the Navy intends to sample these wells using traditional sampling techniques, collect samples in unpreserved polyethylene bottles, and allow suspended sediments to settle from the samples for approximately 2 hours in iced sample coolers. After the settling period, supernatent from these samples will be pumped from the into preserved polyethylene sample bottles for metals analysis.

Electric-sounder water level meters used during groundwater sampling activities will be decontaminated before each use by washing the probe and the portion of the cable directly above the probe with distilled water and wiping those parts clean with a disposable paper towel.

The required volumes of groundwater will be placed in appropriate sample containers for shipment to the laboratory. Purged water will be placed in 55-gallon drums at a designated on-site IDW area until the water is transported off site for disposal.

2.2.2 Decontamination

Drilling equipment, including drill rods, augers, split spoon sampler(s), and the back end of the drill rig, will be steam cleaned before work drilling the RASS 3 monitoring well boring begins. Hand augers, shovels, trowels, water level meters, and any other equipment that may come in contact with sample media will be decontaminated following the practices listed in TtEMI SOP 002 "General Equipment Decontamination" (Appendix B). Nondisposable sampling equipment will be decontaminated before and after collecting each soil sample for analysis. All water derived from decontamination will be collected and temporarily stored on site for characterization as IDW.

2.2.3 Management of Investigation-Derived Waste

IDW will include soil cuttings, purged groundwater, and wastewater from decontamination procedures and collection of equipment rinsate samples. Water and soil IDW will be segregated and stored in U.S. Department of Transportation (DOT)-approved 55-gallon drums at a designated IDW storage area within the Litigation Area. The lids of the drums will be kept closed and secured at all times when the drums are not in use.

The 55-gallon IDW drums will be labeled with a "pending analysis" sticker that identifies the date of IDW collection, the sampling location(s), the sampling personnel, and the waste media. This information will also be recorded in the project logbook.

Environmental samples will provide data that can be used to characterize waste collected during the investigation. Representative samples from the IDW drums, however, may also be collected if they are needed to characterize the waste to determine the most cost-effective disposal methods. One composite soil IDW sample will be analyzed for metals, SVOCs, and pesticides/PCBs. One composite water IDW sample will be analyzed for total metals. IDW will be transported off site for disposal at a licensed facility, in accordance with appropriate federal and state regulations and as the results of its analysis indicate is appropriate.

2.2.4 Sample Containers and Holding Times

The type of sample containers to be used for each analysis, the sample volumes required, the preservation requirements, and the maximum holding times for sample extraction and analysis are presented in Table 9.

2.3 SAMPLE HANDLING AND CUSTODY

The following sections describe sample-handling procedures, including sample identification and labeling, documentation, COC, and shipping.

2.3.1 Location and Sample Identification

Location and sample identification (sample ID) systems were developed for the field investigation to provide methods for tracking each sample through the collection, analysis, validation, and data reduction processes. These two systems were developed to efficiently identify sample locations and analytical results, as well as to provide a means of submitting blind samples to the laboratory.

Samples submitted to the laboratory will have unique identifiers based on a consecutive alphanumeric code. Each sample station will have a unique field identification number that will facilitate the reporting of information about a particular site or sample. The two identification systems, which are described in the following sections, are consistent with the identification systems used at the Litigation Area during the post remediation monitoring program.

2.3.2 Location Identification System

This section describes the location identification system for soil, grab groundwater, and monitoring well groundwater sample locations.

2.3.2.1 Soil and Grab Groundwater Location Identification

The soil and grab groundwater sample locations for further characterizing selected locations of the Litigation Area were based on best professional judgment (Figure 2). These locations are not tied to the sample location grid system set-up for the post remediation monitoring (TtEMI 2000). The numbering for the new sample locations, however, will continue the consecutive numbering from the existing Litigation Area locations. The soil and grab groundwater sample locations will be established by placing a wooden stake at the respective locations.

Sampling locations are denoted by an 8-character identifier as follows:

- The first three characters of the identifier indicate the sampling area:
  - R01 for RASS 1
  - R02 for RASS 2
  - R03 for RASS 3
  - R04 for RASS 4
- The next two characters indicate the type of sampling location:
  - SS for soil
  - GG for grab groundwater

- The last three characters consist of the sample location number. Each of the sample locations for RASSs 1, 2, 3, and 4 have been assigned a unique number during the course of post remediation sampling. The sample locations are generally numbered consecutively from west to east, starting from the north-westernmost location of the Litigation Area to the southeasternmost.

For example, the location R01SS300 indicates a soil sample location in RASS 1, which is the three hundreth consecutively numbered sampling location in RASSs 1, 2, 3, and 4.

2.3.2.2 Monitoring Well Groundwater Location Identification

The 22 existing groundwater monitoring wells at the Litigation Area are identified on Figure 2. The new RASS 3 groundwater monitoring well proposed for this investigation will be identified as well 3MG23 (Figure 2).

2.3.3 Sample Identification System

The sample ID used for the monitoring program will be employed in this field investigation. The sample ID, an 11-character identifier, coordinates the individual sample with the sampling location, depth, and type. The sample ID, which differs from the sample location identifier, was developed to ensure that samples are sent blind to the laboratory. The 11-character identifier will be 105-XXX-YY-ZZZ, where:

- The first three characters indicate the Delivery Order number
- The next three characters (XXX) indicate the sampling area:
  - R01 for RASS 1
  - R02 for RASS 2
  - R03 for RASS 3
  - R04 for RASS 4
- The next two characters (YY) indicate the sample type:
  - SS for soil
  - GG for grab groundwater
  - GW for monitoring well groundwater
- The last three characters (ZZZ) are the consecutive sample number, based on the medium sampled. Three types of media will be for sampled: soil, grab groundwater, and groundwater from monitoring wells. All soil samples collected from a respective RASS will be numbered consecutively among themselves. Similarly, groundwater samples will be numbered consecutively among themselves.

A sample description will be included on each page of COC form, except for the laboratory copy, and will include the sample ID as described above and, if necessary, a descriptive note in parentheses, as in the following examples:

- (0-6″) Denotes top and bottom depth of sample in inches
- (Dup) Denotes duplicate sample
- (Filt) Denotes filtered water sample
- (Rinse) Denotes equipment rinsate blank
- (Source) Denotes decontamination water source blank

2.3.4 Sample Labels

A sample label will be affixed to all sample containers. The label will be completed with the following information written in indelible ink:

- Project name and location
- Sample identification number
- Date and time of sample collection
- Preservative used
- Sample collector’s initials
- Analysis required

After labeling, each sample will be placed in a cooler that contains ice to maintain the sample temperature at or below 4 degrees Celsius (ºC).

2.3.5 Sample Documentation

Documentation during sampling is essential to ensure proper sample identification. TtEMI personnel will adhere to the following general guidelines for maintaining field documentation:

- Documentation will be completed in permanent black ink
- All entries will be legible
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout
- Any serialized documents will be maintained at TtEMI and referenced in the site logbook
- Unused portions of pages will be crossed out, and each page will be signed and dated

Section 1.6.1 includes additional information on how TtEMI will use logbooks to document field activities. The TtEMI field team leader (FTL) is responsible for ensuring that sampling activities are properly documented.

2.3.6 Chain of Custody

TtEMI will use standard sample custody procedures to maintain and document sample integrity during collection, transportation, storage, and analysis. A sample will be considered to be in custody if one of the following statements applies:

- It is in a person’s physical possession or view.
- It is in a secure area with restricted access.
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

COC procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. The COC record (see Appendix C) also will be used to document all samples collected and the analysis requested. Field personnel will record the following information on the COC record:

- Project name and number
- Sampling location
- Name and signature of sampler
- Destination of samples (laboratory name)
- Sample identification number
- Date and time of collection
- Number and type of containers filled
- Analysis requested
- Preservatives used (if applicable)
- Filtering (if applicable)
- Sample designation (grab or composite)
- Signatures of individuals involved in custody transfer, including the date and time of transfer
- Airbill number (if applicable)
- Project contact and phone number

Unused lines on the COC record will be crossed out. Field personnel will sign COC records that are initiated in the field, and the airbill number will be recorded. The record will be placed in a waterproof plastic bag and taped to the inside of the shipping container used to transport the samples. Signed airbills will serve as evidence of custody transfer between field personnel and the courier as well as between the courier and the laboratory. Copies of the COC record and the airbill will be retained and filed by field personnel before the containers are shipped.

Laboratory chain of custody begins when samples are received and continues until samples are discarded. Laboratories analyzing samples on this Navy contract must follow custody procedures at least as stringent as are required by the EPA CLP SOWs (EPA 1999a, 2000e). The laboratory should designate a specific individual as the sample custodian. The custodian will receive all incoming samples, sign the accompanying custody forms, and retain copies of the forms as permanent records. The laboratory sample custodian will record all pertinent information concerning the samples, including the persons delivering the samples, the date and time received, sample condition at the time of receipt (sealed, unsealed, or broken container; temperature; or other relevant remarks), the sample identification numbers, and any unique laboratory identification numbers for the samples. This information should be entered into a computerized laboratory information management system (LIMS). When the sample transfer process is complete, the custodian is responsible for maintaining internal logbooks, tracking reports, and other records necessary to maintain custody throughout sample preparation and analysis.

The laboratory will provide a secure storage area for all samples. Access to this area will be restricted to authorized personnel. The custodian will ensure that samples requiring special handling, including samples that are heat- or light-sensitive, radioactive, or have other unusual physical characteristics, will be properly stored and maintained prior to analysis.

2.3.7 Sample Shipment

The following procedures will be implemented when samples collected during this project are shipped:

- The cooler will be filled with bubble wrap, sample bottles, and packing material. Sufficient packing material will be used to prevent sample containers from breaking during shipment. Enough ice will be added to maintain the sample temperature at or below 4 °C.
- The COC records will be placed inside a plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The air bill, if required, will be filled out before the samples are handed over to the carrier. The laboratory will be notified if the sampler suspects that the sample contains any substance that would require laboratory personnel to take safety precautions.

- The cooler will be closed and taped shut with nylon-reinforced tape around both ends. If the cooler has a drain, it will be taped shut both inside and outside of the cooler.
- Signed and dated custody seals will be placed on the front and side of each cooler. Wide clear tape will be placed over the seals to prevent accidental breakage.
- The COC record will be transported within the taped sealed cooler. When the cooler is received at the analytical laboratory, laboratory personnel will open the cooler and sign the COC record to document transfer of samples.

Multiple coolers may be sent in one shipment to the laboratory. The outside of the coolers will be marked to indicate the number of coolers in the shipment.

2.4 ANALYTICAL METHODS

Table 9 presents the analytical methods that will be used to analyze samples collected during this investigation, and Appendix A presents the project quality assurance (QA) objectives and control limits for sample analyses established as part of the DQO process (Section 1.3). Tables D-1 through D-3 in Appendix D present the individual target analytes required for this investigation and their associated PRRLs. The analytical laboratories will attempt to achieve the PRRLs for all the investigative samples collected. If problems occur in achieving the PRRLs, the laboratories will contact the TtEMI analytical coordinator immediately and other alternatives will be pursued (such as analyzing an undiluted aliquot and allowing nontarget compound peaks to go off-scale) to achieve acceptable reporting limits. In addition, results below the reporting limit but above the MDL will be reported to a concentration of one-half of the PRRL with appropriate flags to indicate the greater uncertainty associated with these values.

The analytical methods required for this investigation include EPA SW-846 methods (EPA 1996). Protocols for laboratory selection and for ensuring laboratory compliance with project analytical and QA/QC requirements are presented in the following subsections.

2.4.1 Selection of Analytical Laboratories

Laboratories for this investigation will be selected from a list of prequalified laboratories developed by TtEMI to support the Navy contract. Prequalification streamlines laboratory selection by reducing the need to compile and review detailed bid and qualification packages for each individual investigation. Prequalification also improves program flexibility by allowing analyses to be directed to a number of different capable laboratories with available capacity at the time samples are collected.

TtEMI's laboratory prequalification and selection process relies on (1) a standard procedure to evaluate and prequalify laboratories for work under the contract, and (2) the "Tetra Tech EM Inc. Laboratory Analytical Statement of Work" for the Navy contract (TtEMI 2002b), a contractual document that specifies standard requirements for analyses that are routinely conducted. TtEMI establishes a basic ordering agreement, incorporating and enforcing the laboratory SOW, with each prequalified laboratory. Individual purchase orders can then be written for specific investigations. These aspects of laboratory selection are further described in the following subsections, along with TtEMI's procedures for selecting laboratories when project-specific analytical methods or QC requirements are not specifically addressed by the laboratory SOW.

2.4.1.1 Laboratory Evaluation and Prequalification

Laboratories that support the Navy either directly or through subcontracts are evaluated and approved for Navy use by the Naval Facilities Engineering Service Center (NFESC). Laboratories that support TtEMI under Navy contracts have been selected from the list of laboratories approved by NFESC and evaluated by TtEMI to assure that the laboratory can meet the technical requirements of the laboratory SOW and produce data of acceptable quality. The evaluation of the laboratories is conducted in accordance with the NFESC *Installation Restoration Chemical Data Quality Manual* (IRCDQM) (NFESC 1999). The laboratory evaluation includes the following elements:

- **Certification and Approval.** Laboratories must be currently certified by the California Department of Health Services (DHS) Environmental Laboratory Accreditation Program (ELAP) for analysis of hazardous materials for each method specified. Laboratories must also have or obtain similar approval from NFESC. The California DHS ELAP certification and NFESC approval must be obtained before the laboratory begins work.
- **Performance Evaluation (PE) Samples.** Each laboratory must initially and yearly demonstrate its ability to satisfactorily analyze single-blind PE samples for all analytical services it will provide under the Navy contract. At its discretion, TtEMI may submit one or more double-blind PE samples at TtEMI's cost. When the results for the PE sample are deficient, the laboratory must correct any problems and analyze (at its own cost) a subsequent round of PE samples for the deficient analysis.

- **Audits.** Laboratories must initially and yearly demonstrate their qualifications by submitting to one or more audits by TtEMI. The audits may consist of (1) an on-site review of laboratory facilities, personnel, documentation, and procedures, or (2) an off-site review of hardcopy and electronic deliverables, or magnetic tapes. When deficiencies are identified, the laboratory must correct the problem and provide TtEMI with a written summary of the corrective action that was taken.

Appendix E provides a current list of subcontractor laboratories that have passed this evaluation program. Each laboratory was evaluated before it was added to the list, and each is reevaluated annually. If a laboratory fails to meet any of the evaluation criteria, it is removed from the list of approved laboratories.

2.4.1.2 TtEMI Laboratory Statement of Work

The laboratory SOW establishes standard requirements for the analytical methods that are most commonly used under the Navy contract. For each method, the laboratory SOW specifies standard method-specific target analyte lists and PRRLs; QC samples and associated control limits; calibration requirements; and miscellaneous method performance requirements. The laboratory SOW also specifies standard data package requirements, EDD formats, data qualifiers, and delivery schedules. In addition, the laboratory SOW outlines support services (such as providing sample containers, trip blanks, sample coolers, and custody forms and seals) that are expected of laboratories. The laboratory SOW incorporates Navy QA policy, as well as applicable EPA and state QA guidelines, as appropriate.

TtEMI’s laboratory SOW is based on EPA CLP methods for VOC, SVOC, pesticides, polychlorinated biphenyls, metals, and cyanide. The laboratory SOW also addresses frequently used non-CLP methods for a variety of organic, inorganic, and physical parameters. Non-CLP methods include EPA SW-846 methods; EPA “Methods for Chemical Analysis of Water and Waste” (MCAWW); ASTM methods; and “Standard Methods for the Examination of Water and Waste Water” published by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Laboratories on TtEMI’s prequalified list can elect to provide all or a portion of the analytical services specified in the laboratory SOW.

As noted above, the laboratory SOW is incorporated into all laboratory subcontracts established for analytical services under Navy contract. Thus, the prequalified laboratories commit to meeting laboratory SOW requirements during the contracting process before they receive samples. TtEMI reviews and revises the laboratory SOW regularly to incorporate new methods and requirements, modifications or updates to existing methods, changes in Navy QA policy or regulatory requirements, and any other necessary corrections or revisions.

2.4.1.3 Laboratory Selection and Oversight

Once project-specific analytical and QA/QC requirements have been determined and documented in the SAP, the TtEMI analytical coordinator works closely with a TtEMI procurement specialist to select a laboratory that can meet these requirements. When project-specific analytical and QC requirements are consistent with TtEMI's laboratory SOW, the analytical coordinator identifies one or more prequalified subcontractor laboratories that are capable of performing the work. As part of this process, the analytical coordinator typically contacts the laboratories to discuss the analytical requirements and project schedule. The analytical coordinator then forwards the name of the recommended laboratory (or laboratories) to the TtEMI procurement specialist, who issues a purchase order for the work. When analytical requirements are consistent with TtEMI's laboratory SOW and multiple prequalified laboratories are capable of performing the work, a specific laboratory is typically selected based on laboratory workload and project schedule considerations.

TtEMI follows a similar procedure when project-specific analytical and QC requirements are nonstandard and differ from those specified in TtEMI's laboratory SOW. The analytical coordinator contacts analytical laboratories, beginning with those on TtEMI's prequalified list, to discuss the analytical and QA/QC requirements in the SAP and to assess the laboratories' ability to meet the requirements. In many cases, TtEMI works cooperatively with analytical laboratories to develop and refine appropriate QC requirements for nonstandard analyses or matrixes.

If the analytical coordinator is unable to identify one or more prequalified laboratories that can perform the work, additional laboratories are contacted. In general, the additional laboratories must be evaluated as described in Section 2.4.1.1 before they will be allowed to analyze any samples, although some evaluation steps may be waived for certain investigations and circumstances (for example, unusual analytes, urgent project needs, experimental methods, mobile laboratories, or on-site screening analysis). After additional laboratories have been identified, the analytical coordinator forwards their names to the procurement specialist. The procurement specialist prepares a solicitation package, including the project-specific analytical and QC requirements, and submits the package to the laboratories. The procurement specialist, in cooperation with the analytical coordinator and project manager, then evaluates the proposals that are received and selects a laboratory that meets the requirements and provides the best value to TtEMI and the Navy. Finally, the procurement specialist issues a purchase order to the selected laboratory that incorporates the project-specific analytical and QA/QC requirements.

After a laboratory has been selected, the analytical coordinator holds a kickoff meeting with the laboratory project manager. The kickoff meeting is held regardless of whether project-specific analytical and QA/QC requirements are consistent with TtEMI's laboratory SOW or are outside the SOW. The TtEMI project manager, procurement specialist, and other key project and laboratory staff may also be involved in this meeting. The kickoff meeting includes a review of analytical and QC requirements in the SAP, the project schedule, and any other logistical support that the laboratory will be expected to provide.

2.4.2 Project Analytical Requirements

For this investigation, one or more prequalified subcontractor laboratories will analyze samples of soil and water off site. The laboratories will be selected before the field program begins based on their ability to meet the project analytical and QC requirements as well as their ability to meet the project schedule. The analytical methods selected for the data gaps evaluation at NWS SBD Concord are standard EPA methods that are described in TtEMI's laboratory SOW. All methods are listed in Table 9 and are from EPA's SW-846 "Test Methods for Evaluating Solid Waste" (EPA 1996).

This SAP documents project-specific QC requirements for the selected analytical methods. Sample volume, preservation, and holding time requirements are specified in Table 9. Requirements for laboratory QC samples are described in Table 4 and in Section 2.5. Appendix A includes project-specific precision and accuracy goals for the methods. Finally, project-required reporting limits for each method are documented in Appendix D.

2.5 QUALITY CONTROL

TtEMI will assess the quality of field data through regular collection and analysis of field QC samples. Laboratory QC samples will also be analyzed in accordance with referenced analytical method protocols to ensure that laboratory procedures and analyses are conducted properly and that the quality of the data is known.

2.5.1 Field Quality Control Samples

QC samples are collected in the field and analyzed to check sampling and analytical precision, accuracy, and representativeness. The following section discusses the types and purposes of field QC samples that will be collected for this project. Table 10 provides a summary of the types and frequency of collection of field QC samples.

TABLE 10

FIELD QC SAMPLES
Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Sample Type	Frequency of Analysis	Matrix
Source Water Blank	1 per source of water used for the final decontamination rinse	Water
Field duplicate	10 percent	Water
Equipment Rinsate	1 per day of soil sampling[a]	Soil

Note:
a TtEMI anticipates one soil sampling event.

2.5.1.1 Field Duplicates

Field duplicate samples are collected at the same time and from the same source and then submitted as separate samples to the laboratory for analysis. Field duplicates will be collected at a frequency of 10 percent for groundwater samples only. Both samples will be assigned a unique sample identification number that is blind to the laboratory.

Although field duplicate soil samples are sometimes collected as soil samples from adjacent locations, such soil duplicate samples will not be collected for this project for two reasons. First, since adjacent soil samples incorporate some spatial variability, these samples cannot be used directly to assess sampling precision. Further, it is not practical to set QC limits for the RPD of such samples, which precludes the use of these samples for QC purposes. Second, while the spatial variability information that can be obtained from adjacent soil samples may be useful in assessing or implementing remedial options, no objectives relating to these data uses have been identified for this project. Rather, it has been determined that this type of spatial variability information will be obtained during subsequent investigations at this site, if required.

2.5.1.2 Equipment Rinsate Samples

Equipment rinsate samples demonstrate whether decontamination procedures are effective in removing contaminants from the field sampling equipment. The presence of contamination in equipment rinsate samples indicates that cleaning procedures were not effective, allowing for the possibility of cross-contamination. Equipment rinsate samples will be collected during soil sampling at a frequency of once per day of sampling. An equipment rinsate is a sample collected after a sampling device is subjected to standard decontamination procedures. Water will be poured over or through the sampling equipment into a sample container and sent to the laboratory for analysis. Analytically certified, organic-free water will be used for organic parameters; deionized or distilled water will be used for inorganic parameters.

Equipment rinsate samples will be sent blind to the laboratory. During data validation, the results for the equipment rinsate samples will be used to qualify data or to evaluate the levels of analytes in the field samples collected on the same day.

2.5.1.3 Source Water Blank Samples

One source water blank will be collected of the water used for the final decontamination rinse. TtEMI anticipates using only one source of water for the final decontamination rinse. The source water blank will be analyzed for all organic and inorganic project analytes (SVOCs, pesticides/PCBs, metals, and pH).

2.5.2 Laboratory Quality Control Samples

Laboratory QC samples are prepared and analyzed at the laboratory to evaluate the effectiveness of sample preparation and analysis and to assess analytical precision and accuracy. The types of laboratory QC samples that will be used for this project are discussed in the following sections. Table 4 presents the required frequencies for laboratory QC samples, and Appendix A presents project-specific precision and accuracy goals for these samples.

2.5.2.1 Method Blanks

Method blanks are prepared to evaluate whether contamination is originating from the reagents used in sample handling, preparation, or analysis. They are critical in distinguishing between low-level field contamination and laboratory contamination. A method blank consists of laboratory analyte-free water and all of the reagents used in the analytical procedure. It is prepared for every analysis in the same manner as a field sample and is processed through all of the analytical steps. Method blanks will be prepared at the frequency prescribed in the individual analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method.

2.5.2.2 Laboratory Control Samples or Blank Spikes

An LCS, or blank spike, originates in the laboratory as deionized or distilled water that has been spiked with standard reference materials of a known concentration. An LCS is analyzed to verify the accuracy of the calibration standards. These internal QC samples are also used to evaluate laboratory accuracy in the presence of matrix interference for field samples. LCSs are processed through the same analytical procedure as field samples. LCSs will be analyzed at the frequency prescribed in the analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method. If percent recovery results for the LCS or blank spike are outside of the established goals, laboratory-specific protocols will be followed to gauge the usability of the data.

2.5.2.3 Matrix Spike and Matrix Spike Duplicates

MS samples measure the efficiency of all the steps in the analytical method in recovering target analytes from an environmental matrix. MS/MSD samples for water matrices require collection of an additional volume of material for laboratory spiking and analysis; for soil matrices, additional sample volume is generally not required. MS/MSD samples will be collected at a frequency of 5 percent for soil and groundwater. The percent recoveries will be calculated for each of the spiked analytes and used to evaluate analytical accuracy. The RPD between spiked samples will be calculated to evaluate precision. Project-specific precision and accuracy goals are presented in Appendix A.

2.5.2.4 Surrogate Standards

Surrogate standards consist of known concentrations of nontarget organic analytes that are added to each sample, method blank, and MS/MSD before samples are prepared and analyzed. The surrogate standard measures the efficiency the analytical method in recovering the target analytes from an environmental sample matrix. Percent recoveries for surrogate compounds are evaluated using laboratory control limits. Surrogate standards provide an indication of laboratory accuracy and matrix effects for every field and QC sample that is analyzed for volatile and extractable organic constituents. Surrogate compounds are used in the analysis of extractable organic compounds to monitor the extraction process and analytical performance.

Factors such as matrix interference and high concentrations of analytes may affect surrogate recoveries. The effects of the sample matrix are frequently outside the control of the laboratory and may present unique problems. Laboratory personnel are required to re-extract (when applicable) and re-analyze samples when associated surrogates are outside of control limits. Data from both analyses of the samples in question are reported.

During validation, data will be qualified as estimated for any result that fails to meet surrogate criteria. SVOC data will be qualified as estimated if two or more surrogates from each fraction (base/neutral and acid) are outside the control limits. The tables in Appendix A provide the guidelines for surrogate recovery for analyses that are planned for this project.

2.5.2.5 Internal Standards

Internal standards are compounds that are added to every SVOC standard, method blank, MS/MSD, and sample or sample extract at a known concentration prior to analysis. Internal standards are used as the basis for quantification of define and add to list GC/MS (GC/MS) target compounds and ensure that the GC/MS sensitivity and response are stable during the analytical run. An internal standard is used to evaluate the efficiency of the sample introduction process and monitors the efficiency of the analytical procedure for each sample matrix encountered. Internal standards may also used in the analysis of organic compounds by GC to monitor retention-time shifts. Validation of internal standards data will be based on EPA protocols presented in guidelines for evaluating organic analyses (EPA 1999b).

2.5.3 Additional Laboratory Quality Control Procedures

In addition to the analysis of laboratory QC samples, subcontractor laboratories will conduct the QC procedures discussed in the following sections.

2.5.3.1 Method Detection Limit Studies

The MDL is the minimum concentration of a compound that can be measured and reported. The MDL is a specified limit at which there is 99 percent confidence that the concentration of the analyte is greater than zero. The MDL takes into account sample matrix and preparation. The subcontractor laboratory will demonstrate the MDLs for all analyses except inorganic analyses and physical properties test methods.

MDL studies will be conducted annually for soil matrices, or more frequently if any method or instrumentation changes. Each MDL study will consist of seven replicates spiked with all target analytes of interest at concentrations no greater than required quantitation limits. The replicates will be extracted and analyzed in the same manner as routine samples. If multiple instruments are used, each will be included in the MDL study. The MDLs reported will be representative of the least sensitive instrument.

2.5.3.2 Sample Quantitation Limits

Sample quantitation limits (SQLs), also referred to as practical quantitation limits, are PRRLs adjusted for the characteristics of individual samples. The PRRLs presented in Appendix D are chemical-specific levels that a laboratory should be able to routinely detect and quantitate in a given sample matrix. The PRRL is usually defined in the analytical method or in laboratory method documentation. The SQL takes into account changes in the preparation and analytical methodology that may alter the ability to detect an analyte, including changes such as use of a smaller sample aliquot or dilution of the sample extract. Physical characteristics such as sample matrix and percent moisture that may alter the ability to detect the analyte are also considered. The laboratory will calculate and report SQLs for all environmental samples.

2.5.3.3 Control Charts

Control charts document data quality in graphic form for specific method parameters such as surrogates and blank spike recoveries. A collection of data points for each parameter is used to statistically calculate means and control limits for a given analytical method. This information is useful in determining whether analytical measurement systems are in control. In addition, control charts provide information about trends over time in specific analytical and preparation methodologies. Although they are not required, TtEMI recommends that subcontractor laboratories maintain control charts for organic and inorganic analyses. At a minimum, method-blank surrogate recoveries and blank spike recoveries should be charted for all organic methods. Blank spike recoveries should be charted for inorganic methods. Control charts should be updated monthly.

2.6 EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

This section outlines the testing, inspection, and maintenance procedures that will be used to keep both field and laboratory equipment in good working condition.

2.6.1 Maintenance of Field Equipment

Preventive maintenance for most field equipment is carried out in accordance with procedures and schedules recommended in (1) the equipment manufacturer’s literature or operating manual, or (2) SOPs that describe equipment operation associated with particular applications of the instrument. However, more stringent testing, inspection, and maintenance procedures and schedules may be required when field equipment is used to make critical measurements.

A field instrument that is out of order will be segregated, clearly marked, and not used until it is repaired. The FTL will be notified of equipment malfunctions so that prompt service can be completed quickly or substitute equipment can be obtained. When equipment condition is suspect, unscheduled testing, inspection, and maintenance should be conducted. Any significant problems with field equipment will be reported in the daily field QC report.

A hollow-stem auger rig will be used to install the monitoring well during the data gaps investigation at the border between RASS 3 and CPC property. The hollow-stem auger rig subcontractor will be required to provide detailed written procedures for inspecting, maintaining, and servicing field equipment available on site.

2.6.2 Maintenance of Laboratory Equipment

Subcontractor laboratories will prepare and follow a maintenance schedule for each instrument used to analyze samples collected for this project. All instruments will be serviced at scheduled intervals necessary to optimize factory specifications. Routine preventive maintenance and major repairs will be documented in a maintenance logbook.

An inventory of items to be kept ready for use in case of instrument failure will be maintained and restocked as needed. The list will include equipment parts subject to frequent failure, parts that have a limited lifetime of optimum performance, and parts that cannot be obtained in a timely manner.

The laboratory’s QA plan and written SOPs will describe specific preventive maintenance procedures for equipment maintained by the laboratory. These documents identify the personnel responsible for major, preventive, and daily maintenance procedures, the frequency and type of maintenance performed, and procedures for documenting maintenance activities.

Laboratory equipment malfunctions will require immediate corrective action. Actions should be documented in laboratory logbooks. No other formal documentation is required unless data quality is adversely affected or further corrective action is necessary. On-the-spot corrective actions will be taken as necessary in accordance with the procedures described in the laboratory QA plan and SOPs.

2.7 INSTRUMENT CALIBRATION AND FREQUENCY

The following sections discuss calibration procedures that will be followed to ensure the accuracy of measurements made using field and laboratory equipment.

2.7.1 Calibration of Field Equipment

Field equipment will be calibrated at the beginning of the field effort and at prescribed intervals. The calibration frequency depends on the type and stability of equipment, the intended use of the equipment, and the recommendation of the manufacturer. Detailed calibration procedures for field equipment are available from the specific manufacturers’ instruction manuals, and general guidelines are included in TtEMI SOPs. All calibration information will be recorded in a field logbook or on field forms. A label that specifies the scheduled date of the next calibration will be attached to the field equipment. If this type of identification is not feasible, equipment calibration records will be readily available for reference.

2.7.2 Calibration of Laboratory Equipment

Laboratory equipment calibration procedures and frequencies will follow the requirements in the reference method in Section 2.4.2 of this SAP. Qualified analysts will calibrate laboratory equipment and document the procedures and results in a logbook.

The laboratory will obtain calibration standards from commercial vendors for both inorganic and organic compounds and analytes. Stock solutions for surrogate standards and other inorganic mixes will be made from reagent-grade chemicals or as specified in the analytical method. Stock standards will also be used to make intermediate standards that will be used to prepare calibration standards. Special attention will be paid to expiration dating, proper labeling, proper refrigeration, and freedom from contamination. Documentation on receipt, mixing, and use of standards will be recorded in the appropriate laboratory logbook. Logbooks must be permanently bound. Additional specific handling and documentation requirements for the use of standards may be provided in subcontractor laboratory QA plans.

2.8 INSPECTION AND ACCEPTANCE OF SUPPLIES AND CONSUMABLES

TtEMI project managers have primary responsibility for identifying the types and quantities of supplies and consumables needed to complete Navy projects and are also responsible for determining acceptance criteria for these items.

Supplies and consumables can be received either at a TtEMI office or at a work site. When supplies are received at an office, the project manager or FTL will sort them according to vendor, check packing slips against purchase orders, and inspect the condition of all supplies before they are accepted for use on a project. If an item does not meet the acceptance criteria, deficiencies will be noted on the packing slip and purchase order, and the item will then be returned to the vendor for replacement or repair.

Procedures for receiving supplies and consumables in the field are similar. When supplies are received, the TtEMI project manager or FTL will inspect all items against the acceptance criteria. Any deficiencies or problems will be noted in the field logbook, and deficient items will be returned for immediate replacement.

Analytical laboratories are required to provide certified clean containers for all analyses. These containers must meet EPA standards described in “Specifications and Guidance for Obtaining Contaminant-Free Sampling Containers” (EPA 1992).

2.9 NON-DIRECT MEASUREMENTS

No data for project implementation or decision-making will be obtained from non-direct measurement sources.

2.10 DATA MANAGEMENT

Field and analytical data collected from this project and other environmental investigations at NWS SBD Concord are critical to site characterization efforts, development of the comprehensive conceptual site model, risk assessments, and selection of remedial actions to protect human health and the environment. An information management system is necessary to ensure efficient access so that decisions based on the data can be made in a timely manner.

After the field and laboratory data reports are reviewed and validated, the data will be entered into TtEMI's database for NWS SBD Concord. The database contains data for (1) summarizing observations on contamination and geologic conditions, (2) preparing reports and graphics, (3) using with geographic information systems, and (4) transmitting in an electronic format compatible with Navy Electronic Data Deliverable (NEDD). The following sections describe TtEMI's data tracking procedures, data pathways, and overall data management strategy for NWS SBD Concord.

2.10.1 Data-Tracking Procedures

All data that are generated in support of this project are tracked through a database created by TtEMI. Information related to the receipt and delivery of samples, project order fulfillment, and invoicing for laboratory and validation tasks is stored in the TtEMI program, SAMTRAK. All data are filed according to the document control number.

2.10.2 Data Pathways

Data are generated from three primary pathways at NWS SBD Concord—data derived from field activities, laboratory analytical data, and validated data. Data from all three pathways must be entered into the NWS SBD Concord database. To evaluate whether the data have been accurately loaded into the database in a timely manner, data pathways must be established and well documented.

Data generated during field activities are recorded using field forms (Appendix C). These forms are reviewed for completeness and accuracy by the analytical coordinator or field team leader. Data from the field forms, including the COC form, are entered into SAMTRAK according to the document control number.

Data generated during laboratory analysis are recorded in hardcopy and in EDDs after the samples have been analyzed. The laboratory will send the hardcopy and EDDs records to the analytical coordinator. The analytical coordinator reviews the data deliverable for completeness, accuracy, and format. After the format has been approved, the electronic data are manipulated and downloaded into the database. TtEMI data entry personnel will then update SAMTRAK with the total number of samples received and number of days required to receive the data.

After validation, the analytical coordinator reviews the data for accuracy. TtEMI will then update the database with the appropriate data qualifiers. SAMTRAK is also updated to record associated laboratory and data validation costs.

2.10.3 Data Management Strategy

TtEMI's short- and mid-term data management strategies require that the database be updated monthly. The data consist of chemical and field data from Navy contractors, entered into an Oracle (Version 7.3) database. The database can be used to generate reports using available computer-aided drafting and design and contouring software. All electronic data from this database will be transmitted in a format compatible with Navy Environmental Data Transfer Standards (NEDTS).

To satisfy long-term data management goals, the data will be loaded into the database at TtEMI for storage, further manipulation, and retrieval after the off-site laboratory and field reports are reviewed and validated. The database will be used to provide data for chemical and geologic analysis and for preparing reports and graphic representations of the data. Additional data acquired from field activities are recorded on field forms (Appendix C) that are reviewed for completeness and accuracy by the analytical coordinator or field team leader. Hard copies of forms, data, and COC forms are filed in a secure storage area according to project and document control numbers. Laboratory data packages and reports will be archived at TtEMI or Navy offices. Laboratories that generated the data will archive hard-copy data for a minimum of 10 years.

3.0 ASSESSMENT AND OVERSIGHT

This section describes the field and laboratory assessments that may be conducted during this project, the individuals responsible for conducting assessments, corrective actions that may be implemented in response to assessment results, and the way quality-related issues will be reported to TtEMI and Navy management.

3.1 ASSESSMENT AND RESPONSE ACTIONS

TtEMI and the Navy will oversee collection of environmental data using the assessment and audit activities described in the following text. Any problems encountered during an assessment of field investigation or laboratory activities will require appropriate corrective action to ensure that the problems are resolved. This section describes the types of assessments that may be completed, TtEMI and Navy responsibilities for conducting the assessments, and corrective action procedures to address problems identified during an assessment.

3.1.1 Field Assessments

TtEMI conducts field technical systems audits (TSA) on selected Navy projects to support data quality and encourage continuous improvement in the field systems that involve environmental data collection. The TtEMI QA program manager selects projects for field TSAs quarterly based on available resources and the relative significance of the field sampling effort. During the field TSA, the assessor will use personnel interviews, direct observations, and reviews of project-specific documentation to evaluate and document whether procedures specified in the approved SAP are being implemented. The following specific items may be observed during the TSA:

- Availability of approved project plans such as this SAP and the base-wide health and safety plan (TtEMI 1998)
- Documentation of personnel qualifications and training
- Sample collection, identification, preservation, handling, and shipping procedures
- Sampling equipment decontamination
- Equipment calibration and maintenance
- Completeness of logbooks and other field records (including nonconformance documentation)

During the TSA, the TtEMI assessor will verbally communicate any significant deficiencies to the FTL for immediate correction. These and all other observations and comments will also be documented in a TSA report. The TSA report will be issued to the TtEMI project manager, FTL, program QA manager, and project QA officer in e-mail format within 7 days after the TSA is completed.

The TtEMI program QA manager determines the timing and duration of TSAs. Generally, TSAs are conducted early in the project so that any quality issues can be resolved before large amounts of data are collected.

The Navy QA officer may also independently conduct a field assessment of any TtEMI project. Items reviewed by the Navy QA officer during a field assessment may be similar to those described previously.

3.1.2 Laboratory Assessments

As described in Section 2.4.1, NFESC assesses all laboratories before they are allowed to analyze samples under Navy contracts. TtEMI also conducts a preaward assessment of each laboratory before they are placed on the approved list for performing work under Navy contracts (Appendix E). These assessments include (1) reviews of laboratory certifications, (2) initial and annual demonstrations of the laboratory's ability to satisfactorily analyze single-blind PE samples, and (3) laboratory audits. Laboratory audits may consist of an on-site review of laboratory facilities, personnel, documentation, and procedures, or an off-site evaluation of the ability of the laboratory's data management system to meet contract requirements. TtEMI also conducts an assessment when an approved laboratory has been selected for nonroutine analyses or when a laboratory that is not on the approved list must be used.

The Navy may audit any laboratory that will analyze samples on this project. The Navy QA officer will determine the need for these audits and will typically conduct the audits before samples are submitted to the laboratory for analysis.

3.1.3 Assessment Responsibilities

TtEMI personnel conducting assessments will be independent of the activity being evaluated. The TtEMI program QA manager will select the appropriate personnel to conduct each assessment and will assign them responsibilities and deadlines for completing the assessment. These personnel may include the program QA manager, project QA officer, or senior technical staff with relevant expertise and assessment experience.

When an assessment is planned, the TtEMI program QA manager selects a lead assessor who is responsible for the following:

- Selecting and preparing the assessment team
- Preparing an assessment plan
- Coordinating and scheduling the assessment with the project team, subcontractor, or other organization being evaluated
- Participating in the assessment
- Coordinating preparation and issuance of assessment reports and corrective action request forms
- Evaluating responses and resulting corrective actions.

After the assessment is completed, the lead assessor will submit an audit report to the TtEMI program QA manger, project manager, and project QA officer; other personnel may be included in the distribution as appropriate. Assessment findings will also be included in a quality summary report for the project (see Section 3.2.3).

The Navy QA officer is responsible for coordinating all audits that may be conducted by Navy personnel under this project. Audit preparation, completion, and reporting responsibilities for Navy auditors would be similar to those described above.

3.1.4 Field Corrective Action Procedures

Field corrective action procedures will depend on the type and severity of the finding. TtEMI classifies assessment findings as either deficiencies or observations. Deficiencies are findings that may have a significant impact on data quality and that will require corrective action. Observations are findings that do not directly affect data quality, but are suggestions for consideration and review.

As described in Section 3.1.1, project teams are required to respond to deficiencies identified in TSA reports. The project manager, FTL, and project QA officer will meet to discuss the deficiencies and the appropriate steps to resolve each deficiency by:

- Determining when and how the problem developed
- Assigning responsibility for problem investigation and documentation
- Selecting the corrective action to eliminate the problem
- Developing a schedule for completing the corrective action
- Assigning responsibility for implementing the corrective action
- Documenting and verifying that the corrective action has eliminated the problem
- Notifying the Navy of the problem and the corrective action taken

In responding to the TSA report, the project team will include a brief description of each deficiency, the proposed corrective action, the individual responsible for determining and implementing the corrective action, and the completion dates for each corrective action. The project QA officer will use a status report to monitor all corrective actions.

The TtEMI program QA manager is responsible for to reviewing proposed corrective actions and verifying that they have been effectively implemented. The program QA manager can require data acquisition to be limited or discontinued until the corrective action is complete and a deficiency is eliminated. The program QA manager can also request the reanalysis of any or all samples and a review of all data acquired since the system was last in control.

3.1.5 Laboratory Corrective Action Procedures

Internal laboratory procedures for corrective action and descriptions of out-of-control situations that require corrective action are contained in laboratory QA plans. At a minimum, corrective action will be implemented when any of the following three conditions occurs: control limits are exceeded, method QC requirements are not met, or sample-holding times are exceeded. The laboratory will report out-of-control situations to the TtEMI analytical coordinator within 2 working days after they are identified. In addition, the laboratory project manager will prepare and submit a corrective action report to the TtEMI analytical coordinator. This report will identify the out-of-control situation and the steps that the laboratory has taken to rectify it.

3.2 REPORTS TO MANAGEMENT

Effective management of environmental data collection requires (1) timely assessment and review of all activities and (2) open communication, interaction, and feedback among all project participants. TtEMI will use the reports described in the following text to address any project-specific quality issues and to facilitate timely communication of these issues.

3.2.1 Daily Progress Reports

TtEMI will prepare a daily progress report to summarize activities throughout the field investigation. This report will describe sampling and field measurements, equipment used, TtEMI and subcontractor personnel on site, QA/QC and health and safety activities, problems encountered, corrective actions taken, deviations from the SAP, and explanations for the deviations. The daily progress report is prepared by the field team leader and submitted to the project manager and to the Navy remedial project manager (RPM), if requested. The content of the daily reports will be summarized and included in the final report submitted for the field investigation.

3.2.2 Project Monthly Status Report

The TtEMI project manager will prepare a monthly status report (MSR) to be submitted to TtEMI’s Navy program manager and the Navy RPM. Monthly status reports address project-specific quality issues and facilitate their timely communication. The MSR will include the following quality-related information:

- Project status
- Instrument, equipment, or procedural problems that affect quality and recommended solutions
- Objectives from the previous report that were achieved
- Objectives from the previous report that were not achieved
- Work planned for the next month

If appropriate, TtEMI will obtain similar information from subcontractors who are participating in the project and will incorporate the information within the MSR.

3.2.3 Quality Control Summary Report

TtEMI will prepare a quality summary report that will be submitted to the Navy RPM with the final report for the field investigation and will include a summary and evaluation of QA/QC activities, including any field or laboratory assessments, completed during the investigation and will indicate the location and duration of storage for the complete data packages. Particular emphasis will be placed on determining whether project DQOs were met and whether data are of adequate quality to support required decisions.

4.0 DATA VALIDATION AND USABILITY

This section describes the procedures that are planned to review, verify, and validate field and laboratory data. This section also discusses procedures for verifying that the data are sufficient to meet DQOs for the project.

4.1 DATA REVIEW, VERIFICATION, AND VALIDATION

Validation and verification of the data generated during field and laboratory activities are essential to obtaining data of defensible and acceptable quality. Verification and validation methods for field and laboratory activities are presented below.

4.1.1 Field Data Verification

Project team personnel will verify field data through reviews of data sets to identify inconsistencies or anomalous values. Any inconsistencies discovered will be resolved as soon as possible by seeking clarification from field personnel responsible for data collection. All field personnel will be responsible for following the sampling and documentation procedures described in this SAP so that defensible and justifiable data are obtained.

Data values that are significantly different from the population are called "outliers." A systematic effort will be made to identify any outliers or errors before field personnel report the data. Outliers can result from improper sampling or measurement methodology, data transcription errors, calculation errors, or natural causes. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in sampling, measurement, transcription, or calculation will be clearly identified in project reports.

4.1.2 Laboratory Data Verification

Laboratory personnel will verify analytical data at the time of analysis and reporting and through subsequent reviews of the raw data for any nonconformances to the requirements of the analytical method. Laboratory personnel will make a systematic effort to identify any outliers or errors before they report the data. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in analysis, transcription, or calculation will be clearly identified in the case narrative section of the analytical data package.

4.1.3 Laboratory Data Validation

An independent third-party contractor will validate all laboratory data in accordance with current EPA national functional guidelines (EPA 1994, 1999b). The data validation strategy will be consistent with Navy guidelines. For this project, 90 percent of the data will undergo cursory validation and 10 percent of the data will undergo full validation. Requirements for cursory and full validation are listed below.

4.1.3.1 Cursory Data Validation

Cursory validation will be completed on 90 percent of the summary data packages for analysis of soil and groundwater samples. The data reviewer is required to notify TtEMI and request any missing information needed from the laboratory. Elimination of the data from the review process is not allowed. All data will be qualified as necessary in accordance with established criteria. Data summary packages will consist of sample results and QC summaries, including calibration and internal standard data.

4.1.3.2 Full Data Validation

Full validation will be completed on 10 percent of the full data packages for analysis of soil and groundwater samples. The data reviewer is required to notify TtEMI and request any missing information needed from the laboratory. Elimination of data from the review process is not allowed. All data will continue through the validation process and will be qualified in accordance with established criteria. Data summary packages will consist of sample results, QC summaries, and all raw data associated with the sample results and QC summaries.

4.1.3.3 Data Validation Criteria

Table 11 lists the QC criteria that will be reviewed for both cursory and full data validation. The data validation criteria selected from Table 11 will be consistent with the project-specific analytical methods listed in Section 2.4 of the SAP.

4.2 RECONCILIATION WITH USER REQUIREMENTS

After environmental data have been reviewed, verified, and validated in accordance with the procedures described in Section 4.1, the data must be further evaluated to determine whether DQOs have been met.

To the extent possible, TtEMI will follow EPA's data quality assessment (DQA) process to verify that the type, quality, and quantity of data collected are appropriate for their intended use. DQA methods and procedures are outlined in EPA's "Guidance for Data Quality Assessment, Practical Methods for Data Analysis" (2000d). The DQA process includes five steps: (1) review the DQOs and sampling design; (2) conduct a preliminary data review; (3) select a statistical test; (4) verify the assumptions of the statistical test; and (5) draw conclusions from the data.

When the five-step DQA process is not completely followed because the DQOs are qualitative in nature, TtEMI will systematically assess data quality and data usability. This assessment will include:

- A review of the sampling design and sampling methods to verify that these were implemented as planned and are adequate to support project objectives
- A review of project-specific data quality indicators for precision, accuracy, representativeness, completeness, comparability, and quantitation limits (defined in Section 1.3.2) to determine whether acceptance criteria have been met
- A review of project-specific DQOs to determine whether they have been achieved by the data collected
- An evaluation of any limitations associated with the decisions to be made based on the data collected. For example, if data completeness is only 90 percent compared to a project-specific completeness objective of 95 percent, the data may still be usable to support a decision, but at a lower level of confidence.

The final report for the project will discuss any potential impacts of these reviews on data usability and will clearly define any limitations associated with the data.

TABLE 11

DATA VALIDATION CRITERIA

Data Gaps Evaluation, Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analytical Parameter Group	Cursory Data Validation Criteria	Full Data Validation Criteria
CLP (Contract Laboratory Program) Organic Analyses	Holding times Calibration Blanks Surrogate recovery Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Internal standard performance Field duplicate sample analysis Overall assessment of data for an SDG (Sample Delivery Group)	Holding times Gas Chromatography/Mass Spectroscopy tuning Calibration Blanks Surrogate recovery Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Internal standard performance Field duplicate sample analysis Compound identification Target compound list identification Compound quantitation and reported detection limits Tentatively identified compounds System performance Overall assessment of data for an SDG
CLP Inorganic Analyses	Holding times Calibration Blanks Matrix spike recovery Matrix duplicate sample analysis Laboratory control sample or blank spike Field duplicate sample analysis Inductively Coupled Plasma (ICP) serial dilution Overall assessment of data for an SDG	Holding times Calibration Blanks ICP interference check sample Matrix spike recovery Matrix duplicate sample analysis Laboratory control sample Field duplicate sample analysis Graphite furnace atomic absorption QC (Quality Control) Sample result verification ICP serial dilution Detection limits Overall assessment of data for an SDG

Analytical Parameter Group	Cursory Data Validation Criteria	Full Data Validation Criteria
Non-CLP Organic Analyses	Method compliance Holding times Calibration Blanks Surrogate recovery Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Internal standard performance Field duplicate sample analysis Other laboratory QC specified by the method Overall assessment of data for an SDG	Method compliance Holding times Calibration Blanks Surrogate recovery Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Internal standard performance Field duplicate sample analysis Compound identification Detection limits Compound quantitation Sample results verification Other laboratory QC specified by the method Overall assessment of data for an SDG
Non-CLP Inorganic and Physical Analyses	Method compliance Holding times Calibration Blanks Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Field duplicate sample analysis Other laboratory QC specified by the method Overall assessment of data for an SDG	Method compliance Holding times Calibration Blanks Matrix spike and matrix spike duplicate recovery Laboratory control sample Field duplicate sample analysis Other laboratory QC specified by the method Detection limits Analyte identification Analyte quantitation Sample results verification Overall assessment of data for an SDG

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APPENDIX A

METHOD PRECISION AND ACCURACY GOALS

(3 Pages)

TABLE A-1

SEMIVOLATILE ORGANIC COMPOUNDS/EPA METHOD 8270C
METHOD PRECISION AND ACCURACY GOALS
Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Spike Limits

Fraction	Spike Compound	Water		Soil	
		% Recovery	RPD	% Recovery	RPD
Base/Neutrals	1,2,4-Trichlorobenzene	39-98	28	38-107	23
	Acenaphthene	46-118	31	31-137	19
	2,4-Dinitrotoluene	24-96	38	28-89	47
	Pyrene	26-127	31	35-142	36
	n-Nitroso-di-n-propylamine	41-116	38	41-126	38
	1,4-Dichlorobenzene	36-97	28	28-104	27
Acids	Pentachlorophenol	9-103	50	17-109	47
	Phenol	12-110	42	26-90	35
	2-Chlorophenol	27-123	40	25-102	50
	4-Chloro-3-methylphenol	23-97	42	26-103	33
	4-Nitrophenol	10-80	50	11-114	50

Surrogate Recovery Limits

Fraction	Surrogate Compound	Water % Recovery	Soil % Recovery
Base/Neutrals	Nitrobenzene-d_5	35-114	23-120
	2-Fluorobiphenyl	43-116	30-115
	p-Terphenyl-d_{14}	33-141	18-137
	1,2-Dichlorobenzene-d_4	16-110	20-130
Acids	Phenol-d_5	10-110	24-113
	2-Fluorophenol	21-100	25-121
	2,4,6-Tribromophenol	10-123	19-122
	2-Chlorophenol-d_4	33-110	20-130

Notes:

EPA U.S. Environmental Protection Agency
RPD Relative percent difference

TABLE A-2

OTHER ANALYSES
METHOD PRECISION AND ACCURACY GOALS
Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

		Matrix Spike[b]		Surrogates[b]
Analyses	**Method[a]**	**% Recovery**	**RPD**	**% Recovery**
Metals	EPA 6010B/7000 Series	70-130	35	75-125

Notes:

a Complete method references are provided in Section 2.4 of this FSP/QAPP.
b Listed criteria will apply to all water and solid matrices.

EPA U.S. Environmental Protection Agency
RPD Relative percent difference

TABLE A-3

CHLORINATED PESTICIDES (EPA METHOD 8081A) AND POLYCHLORINATED BIPHENYLS (EPA METHOD 8082) METHOD PRECISION AND ACCURACY GOALS

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Fraction	Spike Compound	Soil		Water	
		% Recovery	RPD	% Recovery	RPD
Pesticide	Aldrin	74-122	20	70-127	20
	BHC (Lindane)	77-120	20	67-127	20
	4,4'-DDT	83-127	20	73-136	20
	Dieldrin	79-137	20	80-134	20
	Endrin	75-136	20	76-136	20
	Heptachlor	66-135	20	71-140	20
PCB	Aroclor 1260	73-116	20	70-118	20

Surrogate Recovery Limits

Fraction	Surrogate Compound	Water % Recovery	Soil % Recovery
Pesticides/PCB	Tetrachlorometaxylene	88-110	84-138
	Decachlorobiphenyl	86-115	59-113

Notes:

PCB Polychlorinated biphenyl
RPD Relative percent difference

APPENDIX B

STANDARD OPERATING PROCEDURES

SOP No. 002	General Equipment Decontamination	(4 pages)
SOP No. 020	Monitoring Well Installation	(21 pages)
SOP No. 026	Borehole Logging	(14 pages)
SOP No. 021	Monitoring Well Development	(15 pages)
SOP No. 010	Groundwater Sampling	(14 pages)

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GENERAL EQUIPMENT DECONTAMINATION

SOP NO. 002

REVISION NO. 2

Last Reviewed: December 1999

Quality Assurance Approved	*February 2, 1993* Date

1.0 BACKGROUND

All nondisposable field equipment must be decontaminated before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross-contamination.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating equipment in the field.

1.2 SCOPE

This SOP applies to decontaminating general nondisposable field equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

1.3 DEFINITIONS

Alconox: Nonphosphate soap

1.4 REFERENCES

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1.5 REQUIREMENTS AND RESOURCES

The equipment required to conduct decontamination is as follows:

- Scrub brushes
- Large wash tubs or buckets
- Squirt bottles

- Alconox
- Tap water
- Distilled water
- Plastic sheeting
- Aluminum foil
- Methanol or hexane
- Dilute (0.1 N) nitric acid

2.0 PROCEDURE

The procedures below discuss decontamination of personal protective equipment (PPE), drilling and monitoring well installation equipment, borehole soil sampling equipment, water level measurement equipment, and general sampling equipment.

2.1 PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off-site or to clean areas. All used disposable protective clothing, such as Tyvek coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums.

Personnel decontamination procedures will be as follows:

1. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean water. Remove booties and retain boots for subsequent reuse.

2. Wash outer gloves in Liquinox or Alconox solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.

3. Remove Tyvek or coveralls. Containerize Tyvek for disposal and place coveralls in plastic bag for reuse.

4. Remove air purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily or sooner depending on use and application. Place respirator into a separate plastic bag after cleaning and disinfecting.

5. Remove disposable gloves and place them in plastic bag for disposal.

6. Thoroughly wash hands and face in clean water and soap.

2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated at a designated location on-site before drilling operations begin, between borings, and at completion of the project.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casing and screens, and any other equipment that will go into the hole on clean polyethylene sheeting.

The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be containerized.

2.3 BOREHOLE SOIL SAMPLING EQUIPMENT DECONTAMINATION

The soil sampling equipment should be decontaminated after each sample as follows:

1. Prior to sampling, scrub the split-barrel sampler and sampling tools in a bucket using a stiff, long bristle brush and Liquinox or Alconox solution.
2. Steam clean the sampling equipment over the rinsate tub and allow to air dry.
3. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
4. Containerize all water and rinsate.

5. Decontaminate all pipe placed down the hole as described for drilling equipment.

2.4 WATER LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.

2. Rinse with deionized organic-free water.

2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.

2. Maintain the same level of protection as was used for sampling.

3. To decontaminate a piece of equipment, use an Alconox wash; a tap water wash; a solvent (methanol or hexane) rinse, if applicable or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (methanol or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.

4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.

5. Containerize all water and rinsate.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

MONITORING WELL INSTALLATION

SOP NO. 020

REVISION NO. 3

Last Reviewed: December 2000

KRiesing

Quality Assurance Approved

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Date

1.0 BACKGROUND

Groundwater monitoring wells are designed and installed for a variety of reasons including: (1) detecting the presence or absence of contaminants, (2) collecting groundwater samples representative of in situ aquifer chemical characteristics, or (3) measuring water levels for determining groundwater potentiometric head and groundwater flow direction.

Although detailed specifications for well installation may vary in response to site-specific conditions, some elements of well installation are common to most situations. This standard operating procedure (SOP) discusses common methods and minimum standards for monitoring well installation for Tetra Tech EM Inc. (Tetra Tech) projects. The SOP is based on widely recognized methods described by the U.S. Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM). However, well type, well construction, and well installation methods will vary with drilling method, intended well use, subsurface characteristics, and other site-specific criteria. In addition, monitoring wells should be constructed and installed in a manner consistent with all local and state regulations. Detailed specifications for well installation should be identified within a site-specific work plan, sampling plan, or quality assurance project plan (QAPP).

General specifications and installation procedures for the following monitoring well components are included in this SOP:

- Monitoring well materials
  - Casing materials
  - Well screen materials
  - Filter pack materials
  - Annular sealant (bentonite pellets or chips)
  - Grouting materials
  - Tremie pipe
  - Surface completion and protective casing materials
  - Concrete surface pad and bumper posts
  - Uncontaminated water
- Monitoring well installation procedures
  - Well screen and riser placement
  - Filter pack placement
  - Temporary casing retrieval
  - Annular seal placement

  - Grouting
  - Surface completion and protective casing (aboveground and flush-mount)
  - Concrete surface pad and bumper posts
  - Permanent and multiple casing well installation

- Recordkeeping procedures
  - Surveying
  - Permits and well construction records
  - Monitoring well identification

Well installation methods will depend to some extent on the boring method. Specific boring or drilling protocols are detailed in other SOPs. The boring method, in turn, will depend on site-specific geology and hydrogeology and project requirements. Boring methods commonly used for well installation include:

- Hollow-stem augering
- Cable tool drilling
- Mud rotary drilling
- Air rotary drilling
- Rock coring

The hollow-stem auger method is preferred in areas where subsurface materials are unconsolidated or loosely consolidated and where the depth of the boring will be less than 100 feet. This maximum effective depth for hollow-stem augering depends on the diameter of the augers, the formation characteristics, and the strength and durability of the drilling equipment. This method is preferred because under the right conditions it is cost effective, addition of water into the subsurface is limited, continuous soil samples can easily be collected, and monitoring wells can easily be constructed within the hollow augers.

Cable tool drilling is a preferred method when the subsurface contains boulders, coarse gravels, or flowing sands, or when the operational depth of the hollow-stem auger is exceeded. However, this method is slow.

Rotary methods are generally used when other methods cannot be used. The use of drilling fluids or large amounts of water to maintain an open borehole, and the difficulty in obtaining representative samples limit the utility of rotary methods. However, rotary methods can be used to quickly and effectively drill deep wells through consolidated or unconsolidated materials. Modifications to this method such as dual-tube drilling procedures, drill-through casing hammers, or eccentric-type drill systems, can reduce the amount of fluids introduced into the well borehole.

Rock coring is an effective method when drilling in competent consolidated rock. Intact, continuous cores can be obtained, and limited amounts of fluid are required if the formations are not fractured.

1.1 PURPOSE

This SOP establishes the requirements and procedures for monitoring well installation. Monitoring wells should be designed to function properly throughout the duration of the monitoring program. The performance objectives for monitoring well installation are as follows:

- Ensure that the monitoring well will provide water samples representative of in situ aquifer conditions.
- Ensure that the monitoring well construction will last for duration of the project.
- Ensure that the monitoring well will not serve as a conduit for vertical migration of contaminants, particularly vertical migration between discrete aquifers.
- Ensure that the well diameter is adequate for all anticipated downhole monitoring and sampling equipment.

1.2 SCOPE

This SOP applies to the installation of monitoring wells. Although some of the procedures may apply to the installation of water supply wells, this SOP is not intended to cover the design and construction of such wells. The SOP identifies several well drilling methods related to monitoring well installation, but the scope of this SOP does not include drilling methods.

Other relevant SOPs include SOP 002 for decontamination of drilling and well installation equipment, SOP 005 for soil sampling, SOP 021 for monitoring well development, SOPs 010 and 015 for groundwater sampling from monitoring wells, and SOP 014 for measuring static water levels within monitoring wells.

1.3 DEFINITIONS

Annulus: The space between the monitoring well casing and the wall of the well boring.

Bentonite seal: A colloidal clay seal separating the sand pack from the annular grout seal.

Centralizer: A stainless-steel or plastic spacer that keeps the well screen and casing centered in the borehole.

Filter pack: A clean, uniform sand or gravel placed between the borehole wall and the well screen to prevent formation material from entering the screen.

Grout seal: A fluid mixture of (1) bentonite and water, (2) cement, bentonite, and water, or (3) cement and water placed above the bentonite seal between the casing and the borehole wall to secure the casing in place and keep water from entering the borehole.

Tremie pipe: A rigid pipe used to place the well filter pack, bentonite seal, or grout seal. The tremie pipe is lowered to the bottom of the well or area to be filled and pulled up ahead of the material being placed.

Well casing: A solid piece of pipe, typically polyvinyl chloride (PVC) or stainless steel, used to keep a well open in either unconsolidated material or unstable rock.

Well screen: A PVC or stainless steel pipe with openings of a uniform width, orientation, and spacing used to keep materials other than water from entering the well and to stabilize the surrounding formation.

1.4 REFERENCES

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1.5 REQUIREMENTS AND RESOURCES

Well installation requires a completed boring with stable or supported walls. The type of drilling rig needed to complete the boring and the well construction materials required for monitoring well installation will depend on the drilling method used, the geologic formations present, and chemicals of concern in groundwater. The rig and support equipment used to drill the borehole is usually used to install the well. Under most conditions, the following items are also required for the proper installation of monitoring wells:

- Tremie pipe and funnel
- Bentonite pellets or chips
- Grouting supplies
- Casing materials
- Well screen materials
- Filter pack materials

- Surface completion materials (protective casing, lockable and watertight well cover, padlock)
- Electronic water level sounding device for water level measurement
- Measuring tape with weight for measuring the depth of the well and determining the placement of filter pack materials
- Decontamination equipment and supplies
- Site-specific work plan, field sampling plan, health and safety plan, and QAPP
- Monitoring Well Completion Record (see Figure 1)

2.0 MONITORING WELL INSTALLATION PROCEDURES

This section presents standard procedures for monitoring well installation and is divided into three subsections. Section 2.1 addresses monitoring well construction materials, while Section 2.2 describes typical monitoring well installation procedures. Section 2.3 addresses recordkeeping requirements associated with monitoring well installation. Monitoring well installation procedures described in work plans, sampling plans, and QAPPs should be fully consistent with the procedures outlined in this SOP as well as any applicable local and state regulations and guidelines.

2.1 MONITORING WELL CONSTRUCTION MATERIALS

Monitoring well construction materials should be specified in the site-specific work plan as well as in the statement of work for any subcontractors assisting in the well installation. Well construction materials that come in contact with groundwater should not measurably alter the chemical quality of groundwater samples with regard to the constituents being examined. The riser, well screen, and filter pack and annular sealant placement equipment should be steam cleaned or high-pressure water cleaned immediately prior to well installation. Alternatively, these materials can be certified by the manufacturer as clean and delivered to the site in protective wrapping. Samples of the filter pack, annular seal, and mixed grout should be retained as a quality control measure until at least one round of groundwater sampling and analysis is completed.

This section discusses material specifications for the following well construction components: casing, well screen, filter pack, annular sealant (bentonite pellets or chips), grout, tremie pipes, surface completion components (protective casing, lockable and water tight cap, and padlock), concrete surface pad, and uncontaminated water. Figure 2 shows the construction details of a typical monitoring well.

2.1.1 Casing Materials

The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. If the casing has not been certified as clean by the manufacturer or delivered to and maintained in clean condition at the site, the casing should be steam cleaned or high-pressure water cleaned with water from a source of known chemistry immediately prior to installation (see Tetra Tech SOP No. 002). The ends of each casing section should be either flush-threaded or beveled for welding.

Schedule 40 or Schedule 80 PVC casing is typically used for monitoring well installation. Either type of casing is appropriate for monitoring wells with depths less than 100 feet below ground surface (bgs). If the well is deeper than 100 feet bgs, Schedule 80 PVC should be used.

Stainless steel used for well casing is typically Type 304 and is of 11-gauge thickness.

2.1.2 Well Screen Materials

Well screens should be new, machine-slotted or continuous wrapped wire-wound, and composed of materials most suited for the monitoring environment based on site characterization findings. Well screens are generally constructed of the same materials used for well casing (PVC or stainless steel). The screen should be plugged at the bottom with the same material as the well screen. Alternatively, a short (1- to 2-foot) section of casing material with a bottom (sump) should be attached below the screen. This assembly must be able to withstand installation and development stresses without becoming dislodged or damaged. The length of the slotted area should reflect the interval to be monitored.

If the well screen has not been certified as clean by the manufacturer or delivered to and maintained in clean condition at the site, the screen should be steam cleaned or high-pressure water cleaned with water from a source of known chemistry immediately prior to installation (see Tetra Tech SOP No. 002).

The minimum internal diameter of the well screen should be chosen based on the particular application. A minimum diameter of 2 inches is usually needed to allow for the introduction and withdrawal of sampling devices. Typical monitoring well screen diameters are 2 inches and 4 inches.

The slot size of the well screen should be determined relative to (1) the grain size of particles in the aquifer to be monitored and (2) the gradation of the filter pack material.

Screen length and monitoring well diameter will depend on site-specific considerations such as intended well use, contaminants of concern, and hydrogeology. Some specific considerations include the following:

- Water table wells should have screens of sufficient length and diameter to monitor the water table and provide sufficient sample volume under high and low water table conditions.
- Wells with low recharge should have screens of sufficient length and diameter so that adequate sample volume can be collected.
- Wells should be screened over sufficiently short intervals to allow for monitoring of discrete migration pathways.
- Where light nonaqueous-phase liquids (LNAPL) or contaminants in the upper portion of a hydraulic unit are being monitored, the screen should be set so that the upper portion of the water-bearing zone is below the top of the screen.
- Where dense nonaqueous-phase liquids (DNAPL) are being monitored, the screen should be set within the lower portion of the water-bearing zone, just above a relatively impermeable lithologic unit.
- The screened interval should not extend across an aquiclude or aquitard.
- If contamination is known to be concentrated within a portion of a saturated zone, the screen should be constructed in a manner that minimizes the potential for cross-contamination within the aquifer.
- If downhole geophysical surveys are to be conducted, the casing and screen must be of sufficient diameter and constructed of the appropriate material to allow for effective use of the geophysical survey tools.
- If aquifer tests are to be conducted in a monitoring well, the slot size must allow sufficient flux to produce the required drawdown and recovery. The diameter of the well must be sufficient to house the pump and monitoring equipment, and allow sufficient

water flux (in combination with the screen slot size) to produce the required drawdown or recovery.

2.1.3 Filter Pack Materials

The primary filter pack consists of a granular material of known chemistry and selected grain size and gradation. The filter pack is installed in the annulus between the well screen and the borehole wall. The grain size and gradation of the filter pack are selected to stabilize the hydrologic unit adjacent to the screen and to prevent formation material from entering the well during development. After development, a properly filtered monitoring well is relatively free of turbidity.

A secondary filter pack is a layer of material placed in the annulus directly above the primary filter pack and separates the filter pack from the annular sealant. The secondary filter pack should be uniformly graded fine sand, with 100 percent by weight passing through a No. 30 U.S. Standard sieve, and less than 2 percent by weight passing through a No. 200 U.S. Standard sieve.

2.1.4 Annular Sealant (Bentonite Pellets or Chips)

The materials used to seal the annulus may be prepared as a slurry or used as dry pellets, granules, or chips. Sealants should be compatible with ambient geologic, hydrogeologic, and climatic conditions and any man-induced conditions anticipated to occur during the life of the well.

Bentonite (sodium montmorillonite) is the most commonly used annular sealant and is furnished in sacks or buckets in powder, granular, pelletized, or chip form. Bentonite should be obtained from a commercial source and should be free of impurities that may adversely impact the water quality in the well. Pellets are compressed bentonite powder in roughly spherical or disk shapes. Chips are large, coarse, irregularly shaped units of bentonite. The diameter of the pellets or chips should be less than one-fifth the width of the annular space into which they will be placed in order to reduce the potential for bridging. Granules consist of coarse particles of unaltered bentonite, typically smaller than 0.2 inch in diameter. Bentonite slurry is prepared by mixing powdered or granular bentonite with water from a source of known chemistry.

2.1.5 Grouting Materials

The grout backfill that is placed above the bentonite annular seal is ordinarily liquid slurry consisting of either (1) a bentonite (powder, granules, or both) base and water, (2) a bentonite and Portland cement base and water, or (3) a Portland cement base and water. Often, bentonite-based grouts are used when flexibility is desired during the life of the well installation (for example, to accommodate freeze-thaw cycles). Cement- or bentonite-based grouts are often used when cracks in the surrounding geologic material must be filled or when adherence to rock units, or a rigid setting is desired.

Each type of grout mixture has slightly different characteristics that may be appropriate under various physical and chemical conditions. However, quick-setting cements containing additives are not recommended for use in monitoring well installation because additives may leach from the cement and influence the chemistry of water samples collected from the well.

2.1.6 Tremie Pipe

A tremie pipe is used to place the filter pack, annular sealant, and grouting materials into the borehole. The tremie pipe should be rigid, have a minimum internal diameter of 1.0 inch, and be made of PVC or steel. The length of the tremie pipe should be sufficient to extend to the full depth of the monitoring well.

2.1.7 Surface Completion and Protective Casing Materials

Protective casings that extend above the ground surface should be made of aluminum, steel, stainless steel, cast iron, or a structural plastic. The protective casing should have a lid with a locking device to prevent vandalism. Sufficient clearance, usually 6 inches, should be maintained between the top of the riser and the top of protective casing. A water-tight well cap should be placed on the top of the riser to seal the well from surface water infiltration in the event of a flood. A weep hole should be drilled in the casing a minimum of 6 inches above the ground surface to enable water to drain out of the annular space.

Flush-mounted monitoring wells (wells that do not extend above ground surface) require a water-tight protective cover of sufficient strength to withstand heavy traffic. The well riser should be fitted with a locking water-tight cap.

2.1.8 Concrete Surface Pad and Bumper Posts

A concrete surface pad should be installed around each well when the outer protective casing is installed. The surface pad should be formed around the well casing. Concrete should be placed into the formed pad and into the borehole (on top of the grout), typically to a depth of 1 to 3 feet bgs (depending on state, federal, and local regulations). The protective casing is then installed into the concrete. As a general guideline, if the well casing is 2 inches in diameter, the concrete pad should be 3 feet square and 4 inches thick. If the well casing is 4 inches in diameter, the pad should be 4 feet square and 6 inches thick. Round concrete pads are also acceptable.

The finished pad should be sloped so that drainage flows away from the protective casing and off the pad. The finished pad should extend at least 1 inch below grade. If the monitoring wells are located in high traffic areas, a minimum of three bumper posts should be installed around the pad to protect the well. Bumper posts, consisting of steel pipes 3 to 4 inches in diameter and at least 5 feet long, should be installed in a radial pattern around the protective casing, beyond the edges of the cement pad. The base of the bumper posts should be installed 2 feet bgs in a concrete footing; the top of the post should be capped or filled with concrete.

2.1.9 Uncontaminated Water

Water used in the drilling process, to prepare grout mixtures, and to decontaminate the well screen, riser, and annular sealant injection equipment, should be obtained from a source of known chemistry. The water should not contain constituents that could compromise the integrity of the monitoring well installation.

2.2 MONITORING WELL INSTALLATION PROCEDURES

This section describes the procedures used to install a single-cased monitoring well, with either temporary casing or hollow-stem augers to support the walls of the boring in unconsolidated formations. The procedures are described in the order in which they are conducted, and include: (1) placement of well screen and riser pipe, (2) placement of filter pack, (3) progressive retrieval of temporary casing, (4) placement of annular seal, (5) grouting, (6) surface completion and installation of protective casing, and (7) installation of concrete pad and bumper posts.

The additional steps necessary to install a well with permanent or multiple casing strings are described at the end of this section.

2.2.1 Well Screen and Riser Placement

After the total depth of the boring is confirmed and the well screen depth interval and the height of the aboveground completion are determined, the screen and riser is assembled from the bottom up as it is lowered down the hole. The following procedures should be followed:

1. Measure the total depth of the boring using a weighted tape.
2. Determine the length of screen and casing materials required to construct the well.
3. Assemble the well parts from the bottom up, starting with the well sump or cap, well screen, and then riser pipe. Progressively lower the assembled length of pipe.
4. The length of the assembled pipe should not extend above the top of the installation rig.

The well sump or cap, well screen, and riser should be certified clean by the manufacturer or should be decontaminated before assembly and installation. No grease, oil, or other contaminants should contact any portion of the assembly. Flush joints should be tightened, and welds should be water tight and of good quality. The riser should extend above grade and be capped temporarily to prevent entrance of foreign materials during the remaining well completion procedures.

When the well screen and riser assembly is lowered to the predetermined level, it may float and require a method to hold it in place. For borings drilled using cable tool or air rotary drilling methods, centralizers should be attached to the riser at intervals of between 20 and 40 feet.

2.2.2 Filter Pack Placement

The filter pack is placed after the well screen and riser assembly has been lowered into the borehole. The steps below should be followed:

1. Determine the volume of the annular space in the filter pack interval. The filter pack should extend from the bottom of the borehole to at least 2 feet above the top of the well screen.
2. Assemble the required material (sand pack and tremie pipe).
3. Lower a clean or decontaminated tremie pipe down the annulus to within 1 foot of the base of the hole.
4. Pour the sand down the tremie pipe using a funnel; pour only the quantity estimated to fill the first foot.
5. Check the depth of sand in the hole using a weighted tape.
6. Pull the drill casing up ahead of the sand to keep the sand from bridging.
7. Continue with this process (steps 4 through 6) until the filter pack is at the appropriate depth.

If bridging of the filter pack occurs, break out the bridge prior to adding additional filter pack material. For wells less than 30 feet deep installed inside hollow-stem augers, the sand may be poured in 1-foot lifts without a tremie pipe.

Sufficient measurements of the depth to the filter pack material and the depth of the bottom of the temporary casing should be made to ensure that the casing bottom is always above the filter pack. The filter pack should extend 2 feet above the well screen (or more if required by state or local regulations). However, the filter pack should not extend across separate hydrogeologic units. The final depth interval, volume, and type of filter pack should be recorded on the Monitoring Well Completion Record (Figure 1).

A secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack. A measured volume of secondary filter material should be added to extend 1 to 2 feet above the primary filter pack. As with the primary filter pack, a secondary filter pack must not extend into an overlying hydrologic unit. An on-site geologist should evaluate the need for a secondary filter pack by considering the gradation of the primary filter pack, the hydraulic head difference between adjacent units, and the potential for grout intrusion into the primary filter pack.

The secondary filter material is poured into the annular space through tremie pipe as described above. Water from a source of known chemistry may be added to help place the filter pack into its proper location. The tremie pipe or a weighed line inserted through the tremie pipe can be used to measure the top of the secondary filter pack as work progresses. The amount and type of secondary filter pack used should be recorded on the Monitoring Well Completion Record (Figure 1).

2.2.3 Temporary Casing Retrieval

The temporary casing or hollow-stem auger should be withdrawn in increments. Care should be taken to minimize lifting the well screen and riser assembly during withdrawal of the temporary casing or auger. It may be necessary to place the top head of the rig on the riser to hold it down. To limit borehole collapse in formations consisting of unconsolidated materials, the temporary casing or hollow-stem auger is usually withdrawn until the lowest point of the casing or auger is at least 2 feet, but no more than 5 feet, above the filter pack. When the geologic formation consists of consolidated materials, the lowest point of the casing or auger should be at least 5 feet, but no more than 10 feet, above the filter pack. In highly unstable formations, withdrawal intervals may be much less. After each increment, the depth to the primary filter pack should be measured to check that the borehole has not collapsed or that bridging has not occurred.

2.2.4 Annular Seal Placement

A bentonite pellet, chip, or slurry seal should be placed between the borehole and the riser on top of the primary or secondary filter pack. This seal retards the movement of grout into the filter pack. The thickness of the bentonite seal will depend on state and local regulations, but the seal should generally be between 3 and 5 feet thick.

The bentonite seal should be installed using a tremie pipe, lowered to the top of the filter pack and slowly raised as the bentonite pellets or slurry fill the space. Care must be taken so that bentonite pellets or chips do not bridge in the augers or tremie pipe. The depth of the seal should be checked with a weighted tape or the tremie pipe.

If a bentonite pellet or chip seal is installed above the water level, water from a known source should be added to allow proper hydration of the bentonite. Sufficient time should be allowed for the bentonite seal to hydrate. The volume and thickness of the bentonite seal should be recorded on the Monitoring Well Completion Record (Figure 1).

2.2.5 Grouting

Grouting procedures vary with the type of well design. The volume of grout needed to backfill the remaining annular space should be calculated and recorded on the Monitoring Well Completion Record (Figure 1). The use of alternate grout materials, including grouts containing gravel, may be necessary to control zones of high grout loss. Bentonite grouts should not be used in arid regions because of their propensity to desiccate. Typical grout mixtures include the following:

- Bentonite grout: about 1 to 1.25 pounds of bentonite mixed with 1 gallon of water
- Cement-bentonite grout: about 5 pounds of bentonite and one 94-pound bag of cement mixed with 7 to 8 gallons of water
- Cement grout: one 94-pound bag of cement mixed with 6 to 7 gallons of water

The grout should be installed by gravity feed through a tremie pipe. The grout should be mixed in batches in accordance with the appropriate requirements and then pumped into the annular space until full-strength grout flows out at the ground surface without evidence of drill cuttings or fluid. The tremie pipe should then be removed to allow the grout to cure.

The riser should not be disturbed until the grout sets and cures for the amount of time necessary to prevent a break in the seal between the grout and riser. For bentonite grouts, curing times are typically around 24 hours; curing times for cement grouts are typically 48 to 72 hours. However, the curing time required will vary with grout content and climatic conditions. The curing time should be documented in the Monitoring Well Completion Record (Figure 1).

2.2.6 Surface Completion and Protective Casing

Aboveground completion of the monitoring well should begin once the grout has set (no sooner than 24 hours after the grout was placed). The protective casing is lowered over the riser and set into the cured grout. The protective casing should extend below the ground surface to a depth below the frost line (typically 3 to 5 feet, depending on local conditions). The protective casing is then cemented in place. A minimum of 6 inches of clearance should be maintained between the top of the riser and the protective casing. A 0.5-inch diameter drainage or weep hole should be drilled in the protective casing approximately 6 inches above the ground surface to enable water to drain out of the annular space between the casing and riser. A water-tight cap should be placed on top of the riser to seal the well from surface water infiltration in the event of a flood. A lock should be placed on the protective casing to prevent vandalism.

For flush-mounted monitoring wells, the well cover should be raised above grade and the surrounding concrete pad sloped so that water drains away from the cover. The flush-mount completion should be installed in accordance with applicable state and local regulations.

2.2.7 Concrete Surface Pad and Bumper Posts

The concrete pad installed around the monitoring well should be sloped so that the drainage will flow away from the protective casing and off the pad. The finished pad should extend at least 1 inch below grade. If the monitoring wells are located in high traffic areas, a minimum of three bumper posts should be installed in a radial pattern around the protective casing, outside the cement pad. Specifications for concrete surface pads and bumper posts are described in Section 2.1.8.

2.2.8 Permanent and Multiple Casing Well Installation

When wells are installed through multiple saturated zones, special well construction methods should be used to assure well integrity and limit the potential for cross-contamination between geologic zones. Generally, these types of wells are necessary if relatively impermeable layers separate hydraulic units. Two procedures that may be used are described below.

In the first procedure, the borehole is advanced to the base of the first saturated zone. Casing is then anchored in the underlying impermeable layer (aquitard) by advancing the casing at least 1 foot into the aquitard and grouting to the surface. After the grout has cured, a smaller diameter borehole is drilled through the grout. This procedure is repeated until the zone of interest is reached. After the zone is reached, a conventional well screen and riser are set. A typical well constructed in this manner is shown on Figure 3.

A second acceptable procedure involves driving a casing through several saturated layers while drilling ahead of the casing. However, this method is not acceptable when the driven casing may structurally damage a competent aquitard or aquiclude and result in cross-contamination of the two saturated layers. This method should also be avoided when highly contaminated groundwater or nonaqueous-phase contamination may be dragged down into underlying uncontaminated hydrologic units.

2.3 RECORDKEEPING PROCEDURES

Recordkeeping procedures associated with monitoring well installation are described in the following sections. These include procedures for surveying, obtaining permits, completing well construction records, and identifying monitoring wells.

2.3.1 Surveying

Latitude, longitude, and elevation at the top of the riser should be determined for each monitoring well. A permanent notch or black mark should be made on the north side of the riser. The top of the riser and ground surface should be surveyed.

2.3.2 Permits and Well Construction Records

Local and state regulations should be reviewed prior to monitoring well installation, and any required well permits should be in-hand before the driller is scheduled.

Monitoring well installation activities should be documented in both the field logbook and on the Monitoring Well Completion Record (Figure 1). Geologic logs should be completed and, if necessary, filed with the appropriate regulatory agency within the appropriate time frame.

2.3.3 Monitoring Well Identification

Each monitoring well should have an individual well identification number or name. The well identification may be stamped in the metal surface upon completion or permanently marked by using another method. Current state and local regulations should be checked for identification requirements (such as township, range, section, or other identifiers in the well name).

FIGURE 1

MONITORING WELL COMPLETION RECORD

TETRATECH EM INC

MONITORING WELL COMPLETION RECORD

MONITORING WELL

MONITORING WELL NO.: ____________
PROJECT: ____________
SITE: ____________
BOREHOLE NO.: ____________
WELL PERMIT NO.: ____________
TOC TO BOTTOM OF WELL: ____________

DRILLING INFORMATION

DRILLING BEGAN:
DATE: ________ TIME: ________
WELL INSTALLATION BEGAN:
DATE: ________ TIME: ________
WELL INSTALLATION FINISHED:
DATE: ________ TIME: ________
DRILLING CO.: ____________
DRILLER: ____________
LICENSE: ____________
DRILL RIG: ____________
DRILLING METHOD:
❑ HOLLOW-STEM AUGER
❑ AIR ROTARY
❑ OTHER: ____________
DIAMETER OF AUGERS:
ID: ________ OD: ________

WELL CASING

❑ SCHEDULE 40 PVC
❑ OTHER: ____________
PRODUCT: ____________
MFG. BY: ____________
CASING DIAMETER:
ID: ________ OD: ________
LENGTH OF CASING: ____________

WELL SCREEN

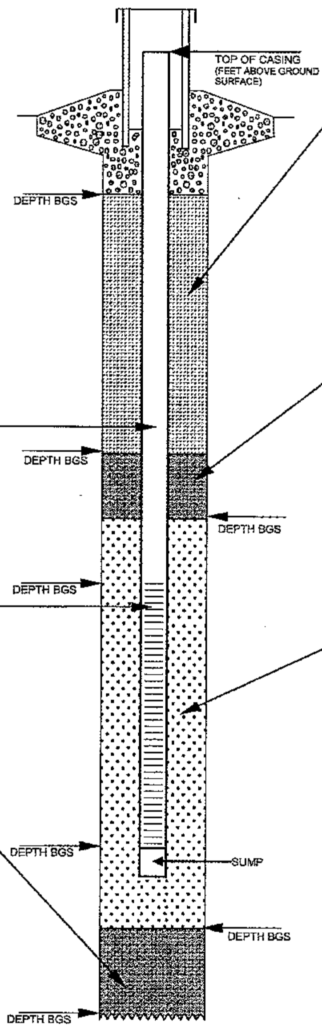
❑ SCHEDULE 40 PVC
❑ OTHER: ____________
PRODUCT: ____________
MFG. BY: ____________
CASING DIAMETER:
ID: ________ OD: ________
SLOT SIZE: ____________
LENGTH OF SCREEN: ____________

BOREHOLE BACKFILL

AMOUNT CALCULATED: ____________
AMOUNT USED: ____________
❑ BENTONITE CHIPS, SIZE: ____________
❑ BENTONITE PELLETS, SIZE: ____________
❑ SLURRY: ____________
❑ FORMATION COLLAPSE: ____________
❑ OTHER: ____________
PRODUCT: ____________
MFG. BY: ____________
METHOD INSTALLED:
❑ POURED ❑ TREMIE
❑ OTHER: ____________

SURFACE COMPLETION

❑ FLUSH MOUNT
❑ ABOVE GROUND WITH BUMPER POST
❑ CONCRETE ❑ ASPHALT



SURVEY INFORMATION

TOC ELEVATION: ____________
GROUND SURFACE ELEVATION: ____________
NORTHING: ____________
EASTING: ____________
DATE SURVEYED: ____________
SURVEY CO.: ____________

ANNULAR SEAL

VOLUME CALCULATED: ____________
AMOUNT USED: ____________
❑ GROUT FORMULA (PERCENTAGES)
PORTLAND CEMENT: ____________
BENTONITE: ____________
WATER: ____________
❑ PREPARED MIX
PRODUCT: ____________
MFG. BY: ____________
METHOD INSTALLED:
❑ POURED ❑ TREMIE
❑ OTHER: ____________

BENTONITE SEAL

VOLUME CALCULATED: ____________
AMOUNT USED: ____________
❑ PELLETS, SIZE: ____________
❑ CHIPS, SIZE: ____________
❑ OTHER: ____________
PRODUCT: ____________
MFG. BY: ____________
METHOD INSTALLED:
❑ POURED ❑ TREMIE
❑ OTHER: ____________
AMOUNT OF WATER USED: ____________

FILTER PACK

❑ PREPACKED FILTER
VOLUME CALCULATED: ____________
AMOUNT USED: ____________
❑ SAND, SIZE: ____________
PRODUCT: ____________
MFG. BY: ____________
METHOD INSTALLED:
❑ POURED ❑ TREMIE
❑ OTHER: ____________
WATER LEVEL: ______
(BTOC AFTER WELL INSTALLATION)

CENTRALIZERS USED?

❑ YES ❑ NO;
CENTRALIZER DEPTHS: ____________

LEGEND

BGS = BELOW GROUND SURFACE
BTOC = BELOW TOP OF CASING
N/A = NOT APPLICABLE
NR = NOT RECORDED
TOC = TOP OF CASING
ID = INSIDE DIAMETER
OD = OUTSIDE DIAMETER

FIGURE 2

MONITORING WELL CONSTRUCTION DIAGRAM

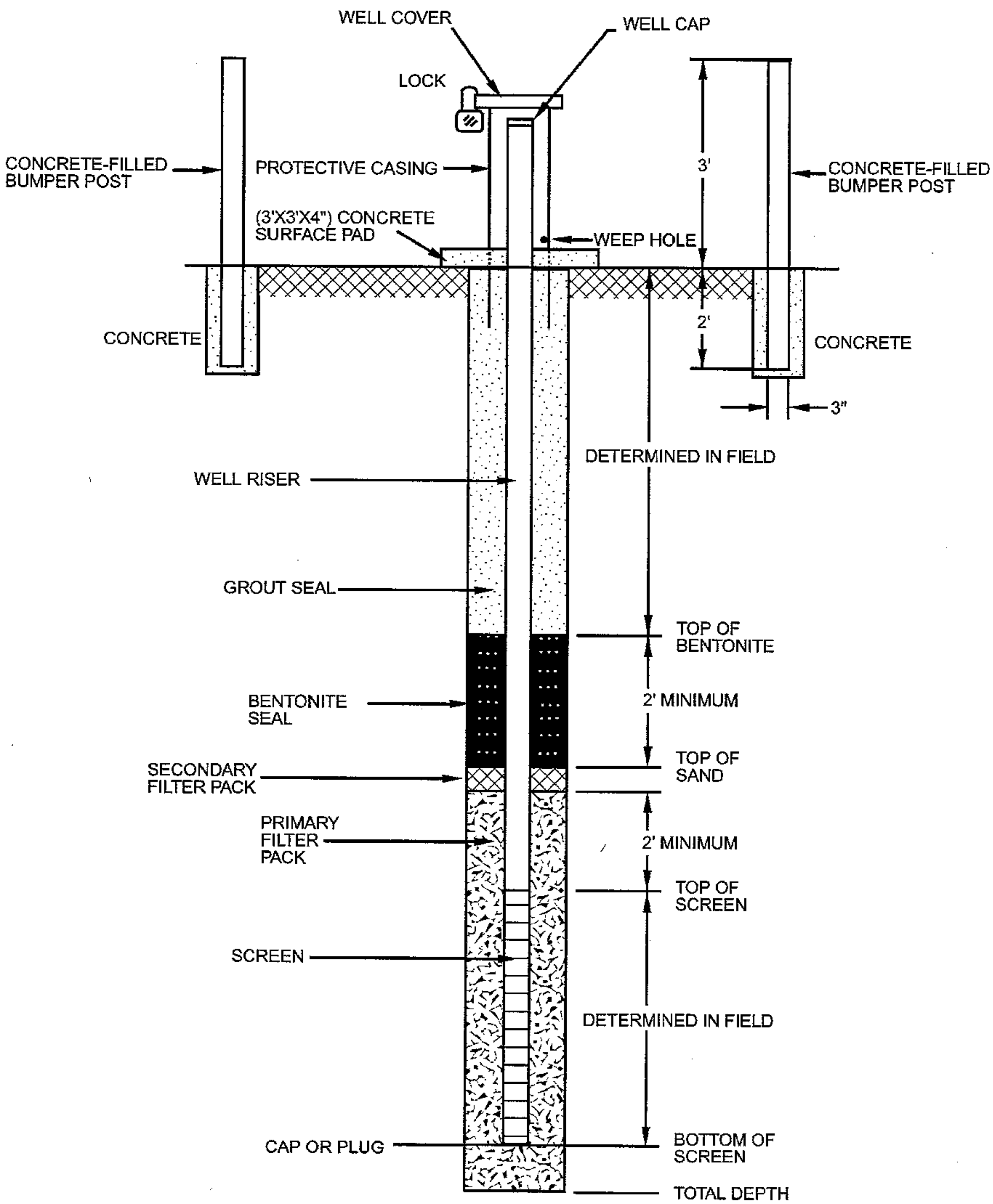
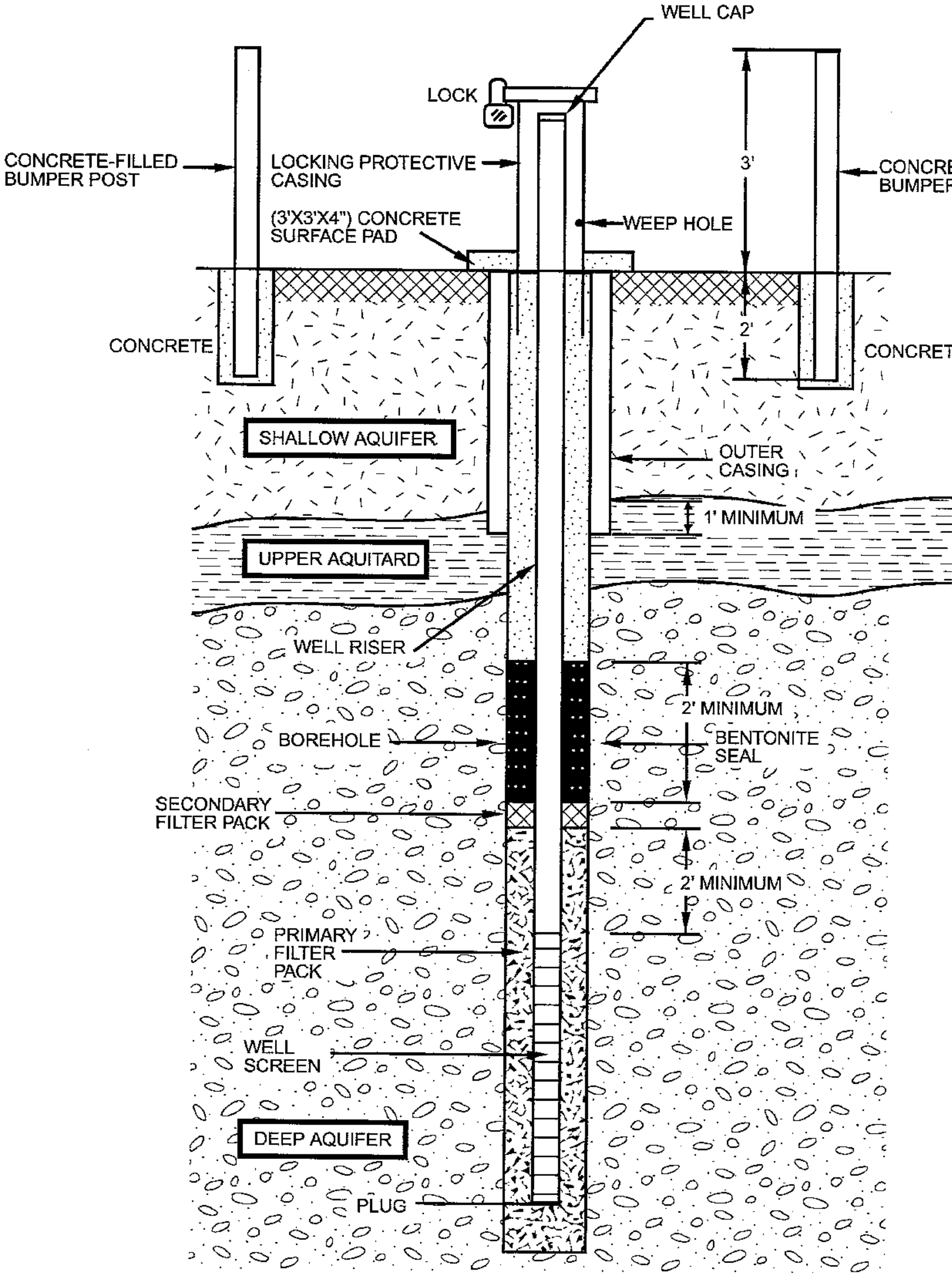


FIGURE 3

MULTIPLE CASING WELL CONSTRUCTION DIAGRAM



SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

BOREHOLE LOGGING

SOP NO. 026

REVISION NO. 2

Last Reviewed: November 1999

February 2, 1993

Quality Assurance Approved | Date

1.0 BACKGROUND

The objective of logging a borehole is to document the details of the soil and rock recovered from the borehole. These details include soil type, color, grain size variation, grain characteristics, staining, odor, moisture content, plasticity, blowcounts, soil sample interval, soil recovery, and sample numbers. These data are used to reconstruct the borehole's stratigraphy, which can then be correlated with similar data from other boreholes in the region to produce geological and hydrogeological cross sections. These cross sections, along with various soil characteristics, and additional hydrogeological data, are used to prepare models that show the migration of groundwater and of any associated contaminants.

Tetra Tech EM Inc. (Tetra Tech) has adopted a modified version of the Unified Soil Classification System (USCS) for borehole logging. The USCS classifies soils based on texture and liquid limits. The system consists of 15 soil groups, each identified by a two-letter symbol. The major divisions within the USCS (the first letter in each two-letter symbol) denote particle size: coarse-grained soils are sands (S) and gravels (G); fine-grained soils are silts (M) and clays (C). In coarse-grained soils, the second letter in the classification refers to the grading (sorting) of the soils. Thus (W) represents clean, well graded (poorly sorted) materials, while (P) represents clean, poorly graded (well sorted) materials. In fine-grained soils, the silts and clays are further subdivided in terms of liquid limits,with (L) indicating soils with low liquid limits and (H) representing soils with high liquid limits.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to ensure that all the pertinent information that can be obtained from drilling a borehole is logged completely, accurately, and consistently.

1.2 SCOPE

This SOP applies to all Tetra Tech personnel involved in the logging of a borehole. Preprinted borehole log forms are available, and all personnel involved in borehole logging will use a form to document field activities. Attachment A contains a sample field borelog form.

1.3 DEFINITIONS

Definitions of terms that relate to borehole logging are presented below. Definitions of soil types are taken from the American Society for Testing and Materials (ASTM 1985).

Blow Counts: The number of blows delivered by a 140-pound hammer dropped 30 inches required to drive a 1.5-inch inside diameter core sampler down a certain depth, generally 6 inches.

Unified Soil Classification System (USCS): A geotechnical classification in which soils are classified into four major divisions (coarse-grained, fine-grained, organic soils, and peat). The coarse-grained soils are classified according to grain size, whereas the fine-grained soils are classified according to plasticity characteristics. A total of 15 soil types are recognized. Each is indicated by a different two-letter group symbol, such as SP, ML, and GW.

Well Graded Sediment/Soil: An engineering term describing a soil or unconsolidated sediment consisting of particles of several or many sizes. The opposite is "poorly graded," in which the soil or sediment particles are of nearly the same size. In the geological literature, "well graded" and "poorly graded" sedimentshoils are referred to as "poorly sorted" and "well sorted," respectively.

Clay: A fine-grained soil passing a No. 200 (75- micron [µm]) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents and that exhibits considerable strength when air-dry.

Gravel: Particles of rock that will pass a 3-inch (75-millimeter [mm]) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions: coarse - passes a 3-inch (75-mm) sieve and is retained on a 0.75-inch (19-mm) sieve; fine -passes a 0.75-inch (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

Organic Clay: A clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 percent of its liquid limit value before oven drying.

Peat: A soil composed primarily of vegetable tissue in various stages of decomposition, usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

Sand: Particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-pm) sieve with the following subdivisions: coarse - passes a No. 4 (4.75-mm) sieve and is retained on No. 10 (2.00-mm) sieve; medium - passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-pm) sieve; fine - passes a No. 40 (425-pm) sieve and is retained on a No. 200 (75-pm) sieve.

Silt: A fine-grained soil passing a No. 200 (75-pm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry.

1.4 REFERENCES

American Geological Institute (AGI). 1972. "Data Sheet." Alexandria, Virginia.

AGI. 1987. *Glossary* of *Geology*. Alexandria, Virginia.

American Society for Testing and Materials (ASTM). 1985. *Annual **Book of** ASTM Standard.* Philadelphia, Pennsylvania.

Fetter, C.W. 1988. *Applied Hydrogeology.* Merrill Publishing Company. Columbus, Ohio.

Holtz, R.D., and W.D. Kovacs. 1981. *An Introduction to Geotechnical Engineering.* Prentice-Hall Inc. Englewood Cliffs, New Jersey.

1.5 REQUIREMENTS AND RESOURCES

To log the borehole, one person at the drill site should be a geoscientist or someone who has a knowledge of soil types and their physical characteristics. The following supplies will be required at the drill site for borehole logging:

Clipboard: Provides a support for completing the field borelog forms. A suitable clipboard measures 12 by 9 inches, is hinged, and of three-leaf metal construction with up to a 1-inch depth for storing papers, borehole log forms, field notebooks, and so on. Tetra Tech has provided a variety of frequently used items such as a laminated color chart, Tetra Tech EM Inc. - Environmental SOP No. 026 USCS table, and examples of soil samples on the metal clipboards for reference in the field.

Borehole Log Form: A preprinted blank form on which all the subsurface information is noted. Tetra Tech has designed and printed this form for all borehole logging purposes. A completed sample field borelog form is presented in Attachment A.

United Soil Classification System (USCS) Table: A USCS table is needed to determine the group to which any retrieved soil belongs. Tetra Tech has laminated a copy of this table on the metal clipboards for reference in the field.

Color Chart: Contains all the possible rock, sediment, and soil colors with which the
material retrieved from the borehole can be compared. In this chart, the color is described (for example, light brownish gray) and given a corresponding color code (for example, 5 YR 6/1). The Munsell Soil Color Chart or the Geological Society of America rock color chart can be used.

Hand Lens: A pocket-size magnifying glass with a magnification of approximately 10 to 20 times. It is particularly helpful in examining fine-grained materials in order to accurately describe the composition, shape, size, roundness, and color of the rock/soil particles.

Pocket Knife: Used to split recovered soil samples in any desired direction. It is also a convenient tool for isolating part of a soil/sediment sample for closer examination.

Hammer: Has many possible uses at the drill site. It is particularly handy for splitting
borehole samples of rocks.

Sample Bottles: Used to collect soil and groundwater samples retrieved during boring.

Ruler: A 1-foot ruler with markings in millimeters and fractions of an inch will be
needed to measure the diameters of coarse-grained sediments.

Adhesive Tape, Scissors, and Markers: Useful for securing the sample bottle caps and for labeling the bottles.

Soil Samples for Reference: Small samples of various soil types that are classified by grain size and roundness. These samples serve as a useful reference in maintaining
consistency in classifying borehole soils at the drill site. Tetra Tech has laminated some examples of prominent soil samples on the metal clipboards for reference in the field.

Hydrochloric Acid: A small bottle of dilute hydrochloric acid (HCI) consisting of one part HCl to three parts water. This will be used to identify calcium carbonate-bearing soils or sediments.

Miscellaneous Reference Charts: These charts include explanations and drawings of technical terms that are frequently used in logging boreholes. Examples include a soil description summary table (see Attachment B), cohesive soil consistency chart, blow counts versus soil stiffness correlation chart, granular soil density chart, moisture table, percentage-composition estimation chart, and particle roundness sketches. Tetra Tech has laminated these charts on metal clipboards for reference in the field.

Photoionization Detector (PID): Used to monitor possible emissions of hazardous gases from the borehole. The unit comes with an operating instruction manual.

Moisture Measuring Unit: Used to measure the moisture content of a soil sample in the field. The unit comes with operating instructions.

Draeger Tube: A colorimetric tube used to measure the concentrations of a variety of inorganic and organic vapors and gases. Allows on-site personnel to take necessary health and safety precautions. The unit comes with operating instructions.

Combustible Gas Indicator: Used to monitor the level of combustible gases that may be present at the drill site. Warns on-site personnel of any danger of explosion. It is of special value for drilling at sites that have a potential for emitting methane.

Work Table: The table is needed to set up equipment, borehole samples, and various
supplies.

Tent or Canopy: Used to protect the field borelog forms and other documents from rain or snow.

2.0 PROCEDURE

The following subsections detail the procedure for borehole logging.

2.1 GETTING ORGANIZED AT THE DRILL SITE

Borehole logging requires setting up a small office and a small laboratory at the drill site. As the borehole material is pulled up and retrieved for sampling, testing, or inspection, a variety of subtasks must becompleted in a certain sequence and in a limited time span. It is

important, therefore, that all the supplies and equipment be well organized and the tasks be clearly understood by the persons who are supposed to log the borehole.

2.2 LOGGING A BOREHOLE

Preprinted borelog forms are available to ensure that pertinent information is recorded by field personnel. Borelog forms will be completed by field personnel during drilling operations.

Instructions for completing the sample form (see Attachments A and B) are given below.

1. General: At the beginning of each day, use a new borelog sheet. The new sheet should continue at the depth where previous day's drilling was terminated.

   Where appropriate, use the following abbreviations:

   M = Missing
   NA = Not applicable
   ND = Not done

2. Location of Borehole: Draw a sketch map of the borehole site in the space provided at the upper left comer of the borelog form. Mark the precise location of the borehole with an "X" and clearly label it (for example, BH-12). Also draw and label prominent features in the vicinity of the borehole, such as railroads, streets, buildings, fencelines, and other landmarks. The direction to north should be shown (TN). Give an approximate scale.

3. Job No., Client, etc.: Enter this information as appropriate. Print the name(s) of the person(s) who logged the segment shown on any particular page of the borelog form.

4. Site, Subsite, Borehole Designation, etc.: This part of the form is self-explanatory. Enter "Sheet__of__" on each page after the borehole is completed.

5. Sampler Type: Choose abbreviations from the following list:

   CHP = Constant head probe
   GP = Geoprobe
   GWP = Groundwater probe
   SGP = Soil-gas probe
   SS = Split spoon
   ST = Shelby tube
   __ = Other (specify)

6. Sample Depth: Record the top and bottom depths of the segment drilled. The fraction of a foot should be recorded in decimals (for example, 5.6 feet) and not in inches.

7. Blows/6" Sampler: Record the number of blows in each 6-inch interval. If more than 100 blows are counted in the 6-inch interval, then record only 100. In this column, the hammer weight should be entered immediately below the blow count for the first entry of each day, after which the hammer weight should be recorded only if it is changed.

8. Inches Recov'd/Driven: This column is self-explanatory.

9. Time: Record the exact time when the sample was collected in military time (for example, 17 15 hours)

10. PID Reading: Record the PID reading in parts per million @pm) units.

11. Analyses (Physical/Chemical): Record the number of containers that will be sent for each type of analysis (physical "Phy" and/or chemical "Chm"). If no sample will be sent for analysis, a zero (0) should be recorded in the appropriate sub-column.

12. Depth in Feet: Enter numerals before or after the preprinted numerals to indicate the depth as multiples of 1 or 10. At the beginning of each day, a new borelog sheet should be used (see item 1 above). The boxes should be used to document soil types and depths.

13. USCS Soil Type: Enter appropriate USCS abbreviations (SW, SP, ML, and so on) based on the soil description in the next column. Complete this column only after the soil types have been described.

14. Soil Description: Record the soil description, noting the following items: soil type, color (with code from the color chart), texture (grain size, roundness, and so on), bedding, odor, consistency (stiffness, plasticity, and so on, for cohesive soils), relative density (loose, dense, and so on, for granular soils), and moisture content (dry, moist, saturated, and so on). The "Field Descriptions for Soil Summary Table" provided in Attachment B can be used to aid in the description formulation process. Record the depth of the water table where it is encountered. The presence of the water table should be indicated by writing down "saturated at __ feet." Soil classified as "sand should be further categorized as well graded (SW) or poorly-graded (SP). It should be remembered that the term "well graded" in geotechnology is the opposite of "well sorted" in geology. Record the sample medium and sample tag number, as necessary.

15. When the borehole is terminated, enter “Borehole terminated at - feet.”

ATTACHMENT A

SAMPLE FIELD BORELOG FORM

FIELD BORELOG

Sheet ____ of ____

Location of Borehole	Job No.:	Borehole Designation
	Client:	Surface Elevation:
	Site:	Depth to Water:
	Subsite:	Logged by:
	Drilling Co.:	Drilling Date(s):
	Drilling Personnel/Method:	

Sampler Type	Sample Depth Top	Sample Depth Bot	Blows /6" Sample	Inches Recov'd /Driven	Time	PID Reading	Analysis Phys	Analysis Chm	Depth (Ft)	USCS Soil Type	Soil Description and Notes
									1		
									2		
									3		
									4		
									5		
									6		
									7		
									8		
									9		
									0		
									1		
									2		
									3		
									4		
									5		
									6		
									7		

ATTACHMENT A

FIELD DESCRIPTIONS FOR SOIL SUMMARY TABLE

ATTACHMENT B

FIELD DESCRIPTIONS FOR SOIL SUMMARY TABLE

FIELD DESCRIPTIONS FOR SOIL

1. TEXTURAL TERMS AND PROPORTIONS OF SOIL CONSTITUENTS

Clay	Silty Sand
Silty Clay	Sand
Clayey Silt	Gravelly Sand
Silt	Sandy Gravel
Sandy Silt	Gravel

Where apparent, indicate approximate percentages of each constituent.

Trace (Minor) ~ 0 to *5* percent
Some ~ *5* to 25 percent
Abundant (clayey, silty, sandy, gravelly) ~ 25 to 50 percent

2. PARTICLE SIZE DISTRIBUTION OR RANGE

(used to modify the textural name and describe the second major constituent)

Very Fine Sand	0.01 to 0.07 mm
Find Sand	0.07 to 0.4 mm
Medium Sand	0.4 to 2 mm
Coarse Sand	2 to 4mm
Very Coarse Sand	4 to 6mm
Granule	4 to 6mm
Gravels	6 mm to 7.5 cm
Cobbles	7.5 to 30 cm
Boulders	>30 cm

3. COLOR (see Munsell Soil Color Chart or GSA rock color chart)

Provide name and code in parentheses.
Where mottled, describe all colors present; where weathered or oxidized, modify with these colors as well.

4. SORTING (use to discuss size distribution when coarser grains predominate)

Well Sorted: ~90 percent of particles in I or 2 size classes
Moderately Sorted: ~90 percent of particles in 3 or 4 size classes
Poorly Sorted: Unsystematic range of particle sizes; no size class predominates
Sorting = Spread of range or degree of similarity

5. PLASTICITY

Nonplastic: Soil falls apart at any water content (crumbly)
Slightly Plastic: Soil easily crushed with fingers; a thread can barely be rolled; low dry strength
Plastic: Soil difficult to crush with fingers; easily rolled thread up to the plastic limit, failure after reaching the plastic limit; medium dry strength.
Very Plastic: Soil impossible to crush with fingers (highly deformable); threads require much time to reach plastic limit and can be rerolled several times after reaching the plastic limit
Plastic limit = Boundary between the plastic and semisolid state (an Atterberg limit)

6. MOISTURE

Dry Slightly Moist Moist Wet

7. DENSITY/CONSISTENCY

Density of Granular Soils

Very Loose	Dense
Loose	Very Dense
Moderately Dense	

Consistency of Cohesive Soils

Very Soft	Stiff (firm)
Soft	Very Stiff (firm)
Moderately Stiff (firm)	Hard (tight)

8. SOIL STRUCTURE

Grade/Uniformity

Structureless (homogeneous)	Moderate
Weak	Strong

Form

Bedding (describe bed thickness)	Imbricated
Stratified	Columnar
Laminated	Prismatic
Banded	Blocky
Platy	Granular

Defects in Soil Structure

Slickensides	Burrows
Roots	Fissures

Cementation	Weathering (type and extent)
Salts	Fresh
Caliche	Depth of weathering
Hardpan	Color

9. MINERALOGY/ANGULARITY

(pertinent for coarse-grained constituents, including sand grains)

General Terms	Specific Terms
Arkosic	Feldspar, Quartz
Felsic (light)	K-Feldspar, Quartz, Plagioclase, Feldspar
Mafic (dark)	Augite, Hornblende, Biotite, Pyroxene
Micaceous	Muscovite, Biotite, Phologopite
Plutonic	Granite, Monzonite, Gabbro
Volcanic	Rhyolite, Latite, Basalt
Oxidized	$Fe0_2$, Limonite
Rock Fragments	

Angularity/Shape

Angular	Rounded
Subangular	Flat
Subrounded	Elongated

10. DESCRIPTION OF SECOND MAJOR CONSTITUENT IF APPLICABLE (refer to horizon boundaries)

11. HORIZON BOUNDARIES

General Terms	Specific Terms
Gradational	Abrupt
Sharp	Diffuse
Erosional	Smooth
Depositional	Wavy
	Irregular
	Broken

12. ENVIRONMENT OF DEPOSITION .

General Terms	Specific Terms (Deposits)
Fill Material	Point Bar
Alluvium	Overbank
Colluvium	Channel
Detritus	Turbidity
Lateritic	Alluvial Fan
Landfill Material	Eolian
	Marine/Bay
	Lagoonal
	Deltaic

13. ADDITIONAL INFORMATION

Sample Designations
For soil or groundwater samples collected from borehole, including Hydropunch

USCS Soil Type
(If not provided in field form)

PID Readings (where taken)
Boreholeiheadspaceldirect sample reading

Drilling Information
Drilling ratelprogress

Terminology
Tight Smooth Chattering

Fluid Type/Fluid Loss
Intervals of loss Quantity lost

Changes in Drilling Methods

Explanation of Downtime

Photographic Information
Photo number (!!) and description, date, time, photographer

Groundwater Information
Initial depth to water
Stabilized depth to water

Miscellaneous Information
Borehole to be converted to monitoring well, weather conditions

EXAMPLE DESCRIPTIONS

(1) Silty clay, about equal silt/clay, mottled olive (5 YR 5/3) to yellowish brown (10 YR 5/6), nonplastic (crumbly), dry, dense, with 1- to 2-mm granules and a 2- to 5-cm lens of coarse quartz sand and gravel, gravels are 3 to 4 mm, rounded, crystalline hard siltstone, sharp contact with GC below, probable fill material, Hnu=0.1 (open sample).
(2) Clay or silty clay with abundant gravel (about 50 percent), medium to large pebbles (I to 2.5 cm), well sorted, subrounded, arkosic; claylsilt hard to distinguish, stained dark gray (10 YR 4/1) to gray (10 YR 5/1) with hydrocarbons, slightly plastic, slightly moist, moderately stiff, uniform, sparse mica or sericite, occasional shell fragments, intertidal marine siltslclays; headspace readings 15-25 ppm; photo #29, stained soils in open split spoon, 10/5/90, 1430, D. West; Sample TP-4 (10-11.5) collected.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

MONITORING WELL DEVELOPMENT

SOP NO. 021

REVISION NO. 3

Last Reviewed: October 2000

K Riesing

Quality Assurance Approved

October 5, 2000

Date

1.0 BACKGROUND

All drilling methods impair the ability of an aquifer to transmit water to a drilled hole. This impairment is typically a result of disturbance of soil grains (smearing) or the invasion of drilling fluids or solids into the aquifer during the drilling process. The impact to the hydrologic unit surrounding the borehole must be remediated so that the well hydraulics and samples collected from the monitoring well are representative of the aquifer.

Well development should be conducted as an integral step of monitoring well installation to remove the finer-grained material, typically clay and silt, from the geologic formation near the well screen and filter pack. (Monitoring well installation is discussed in standard operating procedure [SOP] No. 020.) The fine-grained particles may interfere with water quality analyses and alter the hydraulic characteristics of the filter pack and the hydraulic unit adjacent to the well screen. Well development improves the hydraulic connection between water in the well and water in the formation. The most common well development methods are surging, jetting, overpumping, and bailing.

The health and safety plan for the site should be followed to avoid exposure to chemicals of concern. Water, sediment, and other waste removed from a monitoring well should be disposed of in accordance with applicable federal, state, and local requirements.

1.1 PURPOSE

This SOP establishes the requirements and procedure for monitoring well development. Well development improves the hydraulic characteristics of the filter pack and borehole wall by performing the following functions:

- Reducing the compaction and the intermixing of grain sizes produced during drilling by removing fine material from the pore spaces.
- Removing the filter cake or drilling fluid film that coats the borehole as well as much or all of the drilling fluid and natural formation solids that have invaded the formation.
- Creating a graded zone of sediment around the screen, thereby stabilizing the formation so that the well can yield sediment-free water.

1.2 SCOPE

This SOP applies to the development of newly installed monitoring wells. The SOP identifies the most commonly used well development methods; these methods can be used individually or in combination to achieve the most effective well development. Selection of a particular method will depend on site conditions, equipment limitations, and other factors. The method selected and the rationale for selection should be documented in a field logbook or appropriate project reports.

1.3 DEFINITIONS

Aquifer: A geologic formation, group of formations, or part of a formation that is saturated and capable of storing and transmitting water.

Aquitard: a geologic formation, group of formations, or part of a formation through which virtually no water moves.

Bailer: A cylindrical sampling device with valves on either end, used to extract water from a well or borehole.

Bentonite seal: A colloidal (extremely fine particle that will not settle out of solution) clay seal separating the sand pack from the surface seal.

Drilling fluid: A fluid (liquid or gas) that may be used in drilling operations to remove cuttings from the borehole, to clean and cool the drill bit, and to maintain the integrity of the borehole during drilling.

Filter pack: A clean, uniform sand or gravel placed between the borehole wall and the well screen to prevent formation material from entering the screen.

Grout seal: A fluid mixture of (1) cement and water or (2) cement, bentonite, and water that is placed above the bentonite seal between the casing and the borehole wall to secure the casing in place and keep water from entering the borehole.

Hydraulic conductivity: A measure of the ease with which water moves through a geologic formation. Hydraulic conductivity, K, is typically measured in units of distance per time in the direction of groundwater flow.

Hydrologic units: Geologic strata that can be distinguished on the basis of capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units.

Oil air filter: A filter or series of filters placed in the airflow line from an air compressor to reduce the oil content of the air.

Oil trap: A device used to remove oil from the compressed air discharged from an air compressor.

Riser: The pipe extending from the well screen to or above the ground surface.

Specific conductance: A measure of the ability of the water to conduct an electric current. Specific conductance is related to the total concentration of ionizable solids in the water and is inversely proportional to electrical resistance.

Static water level: The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumpage.

Transmissivity: The volume of water transmitted per unit width of an aquifer over the entire thickness of the aquifer flow, under a unit hydraulic gradient.

Well screen: A cylindrical pipe with openings of a uniform width, orientation, and spacing used to keep materials other than water from entering the well and to stabilize the surrounding formation.

Well screen jetting (hydraulic jetting): A jetting method used for development; nozzles and a high pressure pump are used to force water outwardly through the screen, the filter pack, and sometimes into the adjacent geologic unit.

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1.5 REQUIREMENTS AND RESOURCES

The type of equipment used for well development will depend on the well development method. Well development methods and the equipment required are discussed in Section 2.1 of this SOP. In general, monitoring wells should be developed shortly after they are installed but no sooner than 24 hours after the placement of the grout seal, depending on the grout cure rate and well development method. Most drilling or well development rigs have pumps, air compressors, bailers, surge blocks, and other equipment that can be used to develop a monitoring well.

All downhole equipment should be properly decontaminated before and after each well is developed. See SOP No. 002 (General Equipment Decontamination) for details.

2.0 WELL DEVELOPMENT PROCEDURES

This section describes common well development methods, factors to be considered in selecting a well development method, procedures for initiating well development, well development duration, and calculations typically made during well development. In addition to this, procedures described in any work plans for well development should be fully consistent with local and state regulations and guidelines.

2.1 WELL DEVELOPMENT METHODS

Well development methods vary with the physical characterization of hydrologic units in which the monitoring well is screened and the drilling method used. The most common methods include mechanical surging, overpumping, air lift pumping, backwashing, surge bailing, and well jetting. These methods may be effective alone or may need to be combined (for example, overpumping combined with backwashing). Factors such as well design and hydrogeologic conditions will determine which well development method will be most practical and cost-effective. Commonly used well development methods are described in Sections 2.1.1 through 2.1.6.

The use of chemicals for monitoring well development should be avoided as much as possible. Introduction of chemicals may significantly alter groundwater chemistry in and around the well.

2.1.1 Mechanical Surging

The mechanical surging method forces water to flow in and out of the well screen by operating a plunger (or surge block) in the casing, similar to a piston in a cylinder. A typical surge block is shown in Figure 1. The surge block should fit snugly in the well casing to increase the surging action. The surge block is attached to a drill rod or drill stem and is of sufficient weight to cause the block to drop rapidly on the down stroke, forcing water contained in the borehole into the aquifer surrounding the well. In the recovery stroke or upstroke, water is lifted by the surge block, allowing water and fine sediments to flow back into the well from the aquifer. Down strokes and recovery strokes are usually 3 to 5 feet in length.

The surge block should be lowered into the water column above the well screen. The water column will effectively transmit the action of the block to the filter pack and hydrologic unit adjacent to the well screen. Development should begin above the screen and move progressively downward to prevent the surge block from becoming sand locked in the well. The initial surging action should be relatively gentle, allowing any material blocking the screen to break up, go into suspension, and then move into the well. As water begins to move easily both in and out of the screen, the surge block is usually lowered in increments to a level just above the screen. As the block is lowered, the force of the surging movement should be increased. In wells equipped with long screens, it may be more effective to operate the surge block in the screen to concentrate its actions at various levels.

A pump or bailer should be used periodically to remove dislodged sediment that may have accumulated at the bottom of the well during the surging process. The pump or bailer should be moved up and down at the bottom of the well to suspend and collect as much sediment as possible.

The accumulation of material developed from a specific screen interval can be measured by sounding the total depth of the well before and after surging. Continue surging until little or no sand accumulates.

2.1.2 Overpumping

Overpumping involves pumping the well at a rate substantially higher than it will be pumped during well purging and groundwater sampling. This method is most effective on coarse-grained formations and is usually conducted in conjunction with mechanical surging or backwashing. Overpumping is commonly implemented using a submersible pump. In cases were the water table is less than 30 feet from the top of the casing, it is possible to overpump the well with a centrifugal pump. The intake pipe is lowered into the water column at a depth sufficient to ensure that the water in the well is not drawn down to the pump intake level. The inflow of water at the well screen is not dependent on the location of the pump intake as long as it remains submerged.

Overpumping will induce a high velocity water flow, resulting in the flow of sand, silt, and clay into the well, opening clogged screen slots and cleaning formation voids and fractures. The movement of these particles at high flow rates should eliminate particle movement at the lower flow rates used during well purging and sampling. The bridging of particles against the screen because of the flow rate and direction created by overpumping may be overcome by using mechanical surging or backwashing in conjunction with this method.

2.1.3 Air Lift Pumping

Air lift pumping uses a two-pipe system consisting of an air injection pipe and a discharge pipe. In this well development method, an air lift pump is operated by cycling the air pressure on and off for short periods of time. This operation provides a surging action that can dislodge fine-grained particles in the vicinity of the well screen. Subsequently applying a steady low pressure removes the fines drawn into the well by the surging action.

The bottom of the air lift should be at least 10 feet above the top of the well screen. Air is injected through an inner pipe at sufficient pressure to bubble out directly into the surrounding discharge pipe. The bubbles formed by the injected air cause the column of water in the discharge pipe to be lifted upward and allow water from the aquifer to flow into the well. This arrangement prevents injected air from entering the well screen. Pumping air through the well screen and into the filter pack and adjacent hydrologic unit should be avoided because it can cause air entrainment, inhibiting future sampling efforts and possibly altering groundwater chemistry.

The air injected into the well should be filtered using an oil/air filter and oil trap to remove any compressor lubricant entrained in the air. Air pressures required for this well development method are relatively low; an air pressure of 14.8 pounds per square inch should move a 30-foot column of water. For small-diameter, shallow wells where the amount of development water is likely to be limited, tanks of inert gas (such as nitrogen) can be used as an alternative to compressed air.

2.1.4 Backwashing

Effective development procedures should cause flow reversals through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Backwashing overcomes the bridging that results from overpumping by allowing the water that is pumped to the top of the well to flow back through the submersible pump and out through the well screen. The backflow portion of the backwashing cycle breaks down bridging, and the inflow then moves the fine material toward the screen and into the well.

Some wells respond satisfactorily to backwashing techniques, but the surging effect is not vigorous enough to obtain maximum results in many cases.

A variation of backwashing may be effective in low-permeability formations. After the filter pack is installed on a monitoring well, clean water is circulated down the well casing, out through the well screen and filter pack, and up through the open borehole before the grout or bentonite seal is placed in the annulus. Flow rates should be controlled to prevent floating the filter pack. Because of the low hydraulic conductivity of the formation, negligible amounts of water will infiltrate into the formation. Immediately after this procedure, the bentonite seal should be installed, and the nonformation water should be pumped out of the well and filter pack.

2.1.5 Surge Bailing

Surge bailing can be an effective well development method in relatively clean, permeable formations where water flows freely into the borehole. A bailer made of stainless steel or polyvinyl chloride and slightly smaller than the well casing diameter is allowed to fall freely through the borehole until it strikes the groundwater surface. The contact of the bailer produces a downward force and causes water to flow outward through the well screen, breaking up bridging that has developed around the screen. As the bailer fills and is rapidly withdrawn from the well, the drawdown created causes fine particles to flow through the well screen and into the well. Subsequent bailing can remove these particles from the well. Lowering the bailer to the bottom of the well and using rapid short strokes to agitate and suspend solids that have settled to the well bottom can enhance removal of sand and fine particles. Bailing should continue until the water is free of suspended particles.

2.1.6 Well Jetting

Well jetting can be used to develop monitoring wells in both unconsolidated and consolidated formations. Water jetting can open fractures and remove drilling mud that has penetrated the aquifer. The discharge force of the jetting tool is concentrated over a small area of the well screen. As a result, the tool must be rotated constantly while it is raised and lowered in a very small increments to be sure that all portions of the screen are exposed to the jetting action.

Jetting is relatively ineffective on the fine screens typically used in monitoring wells (slot sizes from 0.01 to 0.02 inch). In addition, jetting requires the introduction of external water into the well and surrounding formation. This water should be obtained from a source of known chemistry. Water introduced for development should be completely removed from the aquifer immediately after development.

The use of compressed air as a jetting agent should not be employed for development of monitoring wells. Compressed air could entrain air in the formation, introduce oil into the formation, and damage the well screen.

2.2 FACTORS TO CONSIDER WHEN SELECTING A WELL DEVELOPMENT METHOD

It is important to check federal, state, and local regulatory requirements for monitoring well development requirements. This SOP may be changed to accommodate applicable regulations, site conditions, or equipment limitations.

The type of geologic material, the design and completion of the well, and the type of drilling method used are all factors to be considered during the development of a monitoring well.

Monitoring well development should usually be started slowly and gently and then performed with increasing vigor as the well is developed. Most well development methods require the application of sufficient energy to disturb the filter pack, thereby freeing fine particles and allowing them to be drawn into the well. The coarser particles then settle around and stabilize the screen.

Development procedures for wells completed in fine sand and silt strata should involve methods that are relatively gentle so that strata material will not be incorporated into the filter pack. Vigorous surging for development can produce mixing of the fine strata and filter pack and produce turbid samples from the formation. In addition, development methods should be carefully selected based upon the potential contaminants present, the quantity of wastewater generated, and requirements for containerization or treatment of wastewater.

For small diameter and small volume wells, a development bailer can be used in place of a submersible pump in the pumping method. Similarly, a bailer can be used in much the same fashion as a surge block in small diameter wells.

Any time an air compressor is used for well development, it should be equipped with an oil air filter or oil trap to minimize the introduction of oil into the screened area. The presence of oil could impact the organic constituent concentrations of the water samples collected from the well.

The presence of light nonaqueous phase liquid (LNAPL) can impact monitoring well development. Water jetting or vacuum-enhanced well development may assist in breaking down the smear zone in the LNAPL. Normal development procedures are conducted in the water-saturated zone and do not affect the LNAPL zone.

2.3 INITIATING WELL DEVELOPMENT

Newly completed monitoring wells should be developed as soon as practical, but no sooner than 24 hours after grouting is completed if rigorous well development methods are used. Development may be initiated shortly after well installation if the development method does not interfere with the grout seal. State and local regulations should be checked for guidance. The following general well development steps can be used with any of the methods described in Section 2.1.

1. Assemble the necessary equipment on a plastic sheet around the well. This may include a water level meter (or oil/water interface probe if LNAPL or dense nonaqueous phase liquid is present); personal protective equipment; pH, conductivity, temperature, and turbidity meters; air monitoring equipment; Well Development Data Sheets (see Figure 2); a watch; and a field logbook.

2. Open the well and take air monitoring readings at the top of the well casing and in the breathing zone. See SOP No. 003 (Organic Vapor Air Monitoring) for additional guidance.

3. Measure the depth to water and the total depth of the monitoring well. See SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement) for additional guidance.

4. Measure the initial pH, temperature, turbidity, and specific conductance of the groundwater from the first groundwater that comes out of the well. Note the time, initial

color, clarity, and odor of the water. Record the results on a Well Development Data Sheet (see Figure 2) or in a field logbook. See SOPs No. 011 (Field Measurement of Water Temperature), 012 (Field Measurement of pH), 013 (Field Measurement of Specific Conductance), and 088 (Field Measurement of Water Turbidity) for additional guidance.

5. Develop the well using one or more of the methods described in Section 2.1 until the well is free of sediments and the groundwater turbidity has reached acceptable levels. Record the development method and other pertinent information on a Well Development Data Sheet see Figure 2) or in a field logbook.

6. Containerize any groundwater produced during well development if groundwater contamination is suspected. The containerized water should be sampled and analyzed to determine an appropriate disposal method.

7. Do not add water to assist in well development unless the water is from a source of known chemical quality and the addition has been approved by the project manager. If water is added, five times the amount of water introduced should be removed during development.

8. Continue to develop the well, repeating the water quality measurements for each borehole volume. Development should continue until each water quality parameter is stable to within 10 percent. Development should also continue until all the water added during development (if any) is removed or the water has a turbidity of less than 50 nephelometric turbidity units. This level may only be attainable after allowing the well to settle and testing at low flow sampling rates.

9. At the completion of well development, measure the final pH, temperature, turbidity, and specific conductance of the groundwater. Note the color, clarity, and odor of the water. Record the results on a Well Development Data Sheet (see Figure 2) or in a field logbook. In addition to the final water quality parameters, the following data should be noted on the Well Development Data Sheet: well identification, date(s) of well installation, date(s) and time of well development, static water level before and after development, quantity of water removed and time of removal, type and capacity of pump or bailer used, and well development technique.

All contaminated water produced during development should be containerized in drums or storage vessels properly labeled with the date collected, generating address, well identification, and consultant contact number.

2.4 DURATION OF WELL DEVELOPMENT

Well development should continue until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction is obtained. When pH, temperature, turbidity, and specific conductance readings stabilize and the water is visually clear of suspended solids, the water is representative of formation water. The minimum duration of well development should vary in accordance with the method used to develop the well. For example, surging and pumping the well may provide a stable, sediment free sample in a matter of minutes, whereas bailing the well may require several hours of continuous effort to obtain a clear sample.

An on-site project geologist should make the final decision as to whether well development is complete. This decision should be documented on a Well Development Data Sheet (see Figure 2) or in a field logbook.

2.5 CALCULATIONS

It is necessary to calculate the volume of water in the well. Monitoring well diameters are typically 2, 3, 4, or 6 inches. The height of water column (in feet) in the well can be multiplied by the following conversion factors to calculate the volume of water in the well casing.

Well Diameter (inches)	Volume (gallon per foot)
2	0.1631
3	0.3670
4	0.6524
6	1.4680

3.0 POTENTIAL PROBLEMS

The following potential problems can occur during development of monitoring wells:

- In some wells the pH, temperature, and specific conductance may stabilize but the water remains turbid. When this occurs, the well may still contain construction materials (such as drilling mud in the form of a mud cake) and formation soils that have not been washed out of the borehole. Excessive or thick drilling muds cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete well development. If the well is completed in a silty zone, it may be necessary to sample with low flow methods or filtering.

- Mechanical surging and well jetting disturb the formation and filter pack more than other well development methods. In formations with high clay and silt contents, surging and jetting can cause the well screen to become clogged with fines. If an excessive amount of fines is produced, sand locking of the surge block may result. Well development with these methods should be initiated gently to minimize disturbance of the filter pack and to prevent damage to the well screen.

- Effective overpumping may involve the discharge of large amounts of groundwater. This method is not recommended when groundwater extracted during well development is contaminated with hazardous constituents. If the hazardous constituents are organic compounds, this problem can be partially overcome by passing the groundwater through an activated carbon filter.

- When a well is developed by mechanical surging or bailing, rapid withdrawal of the surge block or bailer can result in a large external pressure outside of the well. If the withdrawal is too rapid and this pressure is too great, the well casing or screen can collapse.

- A major disadvantage of well jetting is that an external supply of water is needed. The water added during well jetting may alter the hydrochemistry of the aquifer; therefore, the water added in this development procedure should be obtained from a source of known chemistry. In addition, the amount of water added during well development and the amount lost to the formation should be recorded.

- The use of air in well development can chemically alter the groundwater, either directly through chemical reaction or indirectly as a result of impurities introduced through the air stream. In addition, air entrainment within the formation can interfere with the flow of groundwater into the monitoring well. Consequently, air should not be injected in the immediate vicinity of the well screen.

FIGURE 1

SCHEMATIC DRAWING OF A SURGE BLOCK

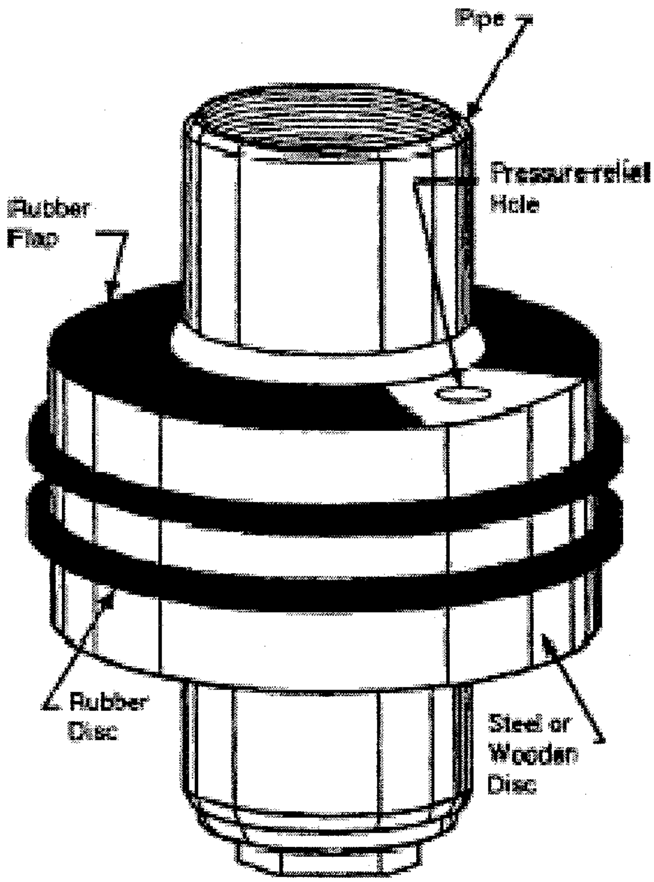

FIGURE 2

WELL DEVELOPMENT DATA SHEET

Sheet ___ of ___

WELL DEVELOPMENT DATA SHEET

BORING NO. ___________ **WELL NO.** ___________

Project ______________________
Project No. ______________________
Date(s) of Installation ______________________
Date(s) of Development ______________________
Personnel/Company ______________________
____
Type of Rig Used ______________________

Casing Diameter/Type ______________________
Borehole Diameter ______________________
Screened Interval(s) ______________________
Total Length of Well Casing ______________________
Measured Total Depth (TOC) Initial ______________
Final ______________
Initial Depth to Water
(TOC) ____________ Date ________ Time ________
Stabilized Depth to Water
(TOC) ____________ Date ________ Time ________

DEVELOPMENT TECHNIQUE(S) — EQUIPMENT TYPE/CAPACITY

___ Surging ______________________
___ Overpumping ______________________
___ Air Lift Pumping ______________________
___ Backwashing ______________________
___ Bailing ______________________
___ Well Jetting ______________________

FLUIDS ADDED

Lost Drilling Fluid: ____________ Gallons
Lost Purge Water: ____________ Gallons
Water During Installation: ____________ Gallons
Total Fluids Added: ____________ Gallons
Source of Added Water: ______________________
Sample Collected of Added Water: Y N
Sample Designation of Added Water: ______________________

PURGE VOLUME CALCULATION

Casing Volume: __________ Ft. of water
x __________ Gallons/Foot
= __________ Gallons per Single Casing Volume
Sand Pack Volume: __________ Ft. of Saturated Sand Pack
x __________ Gallons/Foot (borehole diameter)
= __________ Gallons (in borehole)
- __________ Gallons of Casing Volume
= __________ x 0.3 (Assuming porosity = 30%)
= __________ Gallons Within Sand Pack
Single Purge Volume: __________ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)
Minimum Purge Volume: __________ Gallons
Actual Purge Volume: __________ Gallons
Volume Measured by: ______________________
Rate of Development ________ Gallons/Minute (Hour, Day)
Pumping Rate/Depth __________ @ ______ Ft. (Below Grd.)
Immiscible Phases Present: Y N Thickness __________

Development Criteria: ______________________

Total Volume Discharged	Rate of Discharge	Time	Temp	pH	Specific* Conductance	Turbidity (NTU)	D.O., Clarity, Odor, PID Readings, Other:

Development Completed at ______________ Gallons Discharged. Date: __________ Time: __________

Personnel: ______________________
____

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING

SOP NO. 010

REVISION NO. 3

Last Reviewed: March 2000

	February 19, 1993
Quality Assurance Approved	Date

1.0 BACKGROUND

Groundwater sampling may be required for a variety of reasons, such as examining potable or industrial water supplies, checking for and tracking contaminant plume movement in the vicinity of a land disposal or spill site, Resource Conservation and Recovery Act (RCRA) compliance monitoring, or examining a site where historical information is minimal or non-existent, but where groundwater may be contaminated.

Groundwater is usually sampled through an in-place well, either temporarily or permanently installed. However, it can also be sampled anywhere groundwater is present, such as a pit or a dug or drilled hole.

Occasionally, a well will not be in the preferred location to obtain the sample needed (for example, to track a contaminant plume). In such a case, a temporary or permanent well will have to be installed. An experienced and knowledgeable person, preferably a hydrogeologist, will need to locate the well and supervise its installation so that the samples ultimately collected will be representative of the groundwater. SOP No. 020 (Monitoring Well Installation) provides guidance for installing new monitoring wells.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for determining the quality of groundwater entering, leaving, or affected by site activities through groundwater sampling. The samples are obtained by retrieving water from a well screened in the aquifer(s) underlying a site.

1.2 SCOPE

This SOP provides general guidance for groundwater sampling activities conducted in the field. SOP No. 015 (Groundwater Sample Collection Using Micropurge Technology) provides additional specific guidance for using low flow methods to collect groundwater samples.

1.3 DEFINITIONS

Bailer: A cylindrical sampling device with valves on either end used to extract water from a well. Bailers are usually constructed of an inert material such as stainless steel or polytetrafluoroethylene (Teflon). The bailer is lowered and raised by means of a cable that may be cleaned and reused, or by disposable rope.

Electrical Water Level Indicator: An electrical device that has a light or sound alarm connected to an open circuit used to determine the depth to liquid. The circuit is closed when the probe intersects a conducting liquid. The wire used to raise and lower the probe is usually graduated.

Immiscible Phase: Liquid phases that cannot be uniformly mixed or blended with water. Heavy immiscible phases sink, and light immiscible phases float on water.

Interface Probe: An electrical probe that determines the distance from the surface to air/water, air/immiscible, or immiscible/water interfaces.

Purge Volume: The volume of water that needs to be removed from the well prior to sampling to ensure that the sample collected is representative of the groundwater.

Riser Pipe: The length of well casing above the ground surface.

Total Well Depth: The distance from the ground surface to the bottom of the well.

Water Level: The level of water in a well, measured as depth to water or as elevation of water, relative to a reference mark or datum.

1.4 REFERENCES

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1.5 REQUIREMENTS AND RESOURCES

There are various options available to obtain groundwater samples. The procedures are outlined in the following section. The equipment needed to accomplish these procedures includes the following:

- Organic vapor detector with a flame ionization detector (FID) or a photoionization detector (PID)
- Pipe wrench
- Electrical water level indicator or interface probe
- Steel tape with heavy weight
- Purging device (type needed depends on well depth, casing diameter, and type of sample desired; see sampling devices below)
- Sampling device (type needed depends upon depth to water and type of sample desired)
  - Teflon bailer
  - Stainless steel bailer
  - Teflon bladder pump
  - Stainless steel submersible (nonoil-bearing) pump
  - Existing dedicated equipment
  - Peristaltic pump
- Sample containers
- Wastewater containers
- Field logbook
- Stopwatch

Additional equipment is required to complete measurement of field parameters (for example, pH, specific conductance, and temperature) of the groundwater in the well.

2.0 PROCEDURE

Prior to sampling, a site-specific sampling plan should be developed. The plan should take into consideration the site characteristics and should include:

- Specific repeatable well measurement techniques and reference points for determining the depth to water and the depth to the bottom of the well
- Specific method of purging and selection of purging equipment
- Specific methods and equipment for measurements of field parameters
- Specific method of sample collection and the sampling equipment that will be used
- Specific parameters for which samples will be analyzed
- Order in which sample bottles will be filled, based on the analytical parameters

The following sections discuss procedures for approaching the well, establishing a sample preparation area, making preliminary well measurements, purging the well, and collecting samples.

2.1 APPROACHING THE WELL

In general, all wells should be assumed to pose a health and safety risk until field measurements indicate otherwise. Approach wells from the upwind side. Record well appearance and general condition of the protective casing, surface seal, and surrounding area in the logbook.

Once at the well, the lead person should systematically use the organic vapor detector to survey the immediate area around the well (from the breathing zone to the top of the casing to the ground). If elevated FID and PID meter readings are encountered, retreat to a safe area and instruct the sampling team to put on the appropriate level of personal protective equipment (PPE). See SOP No. 003 (Organic Vapor Air Monitoring) for additional guidance.

Upon opening the well casing, the lead person should systematically survey inside the well casing, above the well casing in the breathing zone and the immediate area around the well. If elevated FID or PID meter readings in the breathing zone are encountered (see health and safety plan for action levels), retreat and put on appropriate PPE. It is important to remember that action levels are based on readings in the breathing zone, not within the well casing. Representative organic vapor detector readings should be recorded in the logbook.

2.2 ESTABLISHING A SAMPLE PREPARATION AREA

The sample preparation area is generally located upwind or to either side of the well. If elevated readings are encountered using an organic vapor detector, this area should be taped off and the sample preparation area should be located upwind where ambient readings are found.

2.3 MAKING PRELIMINARY WELL MEASUREMENTS

Several preliminary well measurements should be made prior to initiating sampling of the well. These include determining water level and total well depth measurements, determining the presence of immiscible phases, and calculating purge volumes. All preliminary measurements will be recorded in the logbook as they are determined. SOP No. 014 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement) provides additional information concerning these preliminary measurements.

2.3.1 Water Level and Total Well Depth Measurements

Tetra Tech typically uses an electric water level indicator for water level measurements. This device sounds an alarm or illuminates a light when the measuring probe touches the water surface, thus closing an electrical circuit. The electric cable supporting the probe is usually graduated in feet and can be read at the well site directly. The remaining fraction is measured with a steel tape graduated to 0.01 foot. The distance between the static water level and the marked or notched location at the top of the riser pipe is measured. The height of the riser pipe above ground surface, as obtained from well location survey data, is then subtracted from the total reading to give the depth to static water. To improve accuracy, three separate readings should be made, and the values averaged. This helps to eliminate any errors due to kinks or bends in the cables, which may change in length when the water level indicator is raised and lowered.

The total well depth can be measured by using a steel tape with a heavy weight attached to the end. The tape is lowered into the well until resistance is met, indicating that the weight has reached the bottom of the well. The total well depth is then read directly from the steel tape to the 0.01-foot fraction. The distance between the bottom of the well and the marked or notched location on the riser pipe is measured. The height of the riser pipe above the ground surface, as obtained from well survey data, is then subtracted from the total reading to give the depth to the bottom of the well. To improve accuracy, three separate readings should be made, and the readings averaged.

2.3.2 Determining If Immiscible Phases Are Present

If immiscible phases (organic floaters or sinkers) are present, the following measurement activities should be undertaken. Organic liquids are measured by lowering an interface probe slowly to the surface of the liquid in the well. When the audible alarm sounds, record the depth. If the alarm is continuous, a floating immiscible layer has been detected. To determine the thickness of this layer, continue lowering the probe until the alarm changes to an oscillating signal. The oscillating signal indicates that the probe has detected an aqueous layer. Record this depth as the depth to water and determine the thickness and the volume of the immiscible layer.

Continue lowering the probe into the well to determine if dense immiscible phases (sinkers) are present. If the alarm signal changes from oscillating to a continuous sound, a heavier immiscible layer has been detected; record this depth.

Continue lowering the probe to the bottom of the well and record the total depth. Separate total depth measurements with a steel tape are not necessary when using an interface probe. Calculate and record the sinker phase volume and total water volume in the well. A chart is provided in Table 1 to assist in these calculations. If immiscible phases are present, immediately refer to Section 2.5.3 or 2.5.4 of this SOP.

2.3.3 Determination of Purging Volume

If the presence of floaters or sinkers does not need to be determined, determine the depth to water and the total depth of the well as described in Section 2.3.1. Once these measurements have been made and recorded, use Table 1 to calculate the total volume of water in the well. Multiply this volume by the purging factor to determine purging volume. The minimum purging factor is typically three casing volumes but may be superseded by site-specific program requirements, individual well yield characteristics, or stabilization of field parameters measured during purging. Field parameters (for example, pH, specific conductance, and temperature) should be measured prior to purging and after each well volume. All field parameter data should be recorded in the field logbook. SOPs No. 011 (Field Measurement of Water Temperature), 012 (Field Measurement of pH), and 013 (Field Measurement of Specific Conductance) include more detailed procedures for determining these field parameters.

In Table 1, the volume of water in a 1-foot section of a 2-inch-diameter well is 0.163 gallon. This chart can easily be used for any water depth by multiplying all the values in Table 1 by the L value (depth, in feet, of water in the well). The volume of water in the well is based on the following formula:

$$V = \frac{\pi \times D^2}{4} \times L$$

where

V = volume of water in the well (cubic feet)
D = inside diameter of the well (feet)
L = depth of water in the well (feet)

2.4 PURGING THE WELL

Currently, Tetra Tech standards allow for six options for purging wells:

1. Teflon bailers
2. Stainless steel bailers
3. Teflon bladder pumps
4. Stainless steel submersible (nonoil-bearing) pumps
5. Existing dedicated equipment
6. Peristaltic pumps (these devices are for shallow wells only)

As previously stated, the minimum purging volume is typically three casing volumes. Exceptions to this standard may be made in the case of low-yield wells. When purging low-yield wells, purge the well once to dryness. Samples should be collected as soon as the well recovers. When the time required for full recovery exceeds 3 hours, samples should be collected as soon as sufficient groundwater volume is available.

The well should be purged until measured field parameters have stabilized. If any field parameter has not stabilized, additional purging should be performed. To be considered stable, field parameters should change by no more than the tolerance levels listed on Table 2 between each well volume purged.

At no time should the purging rate be high enough to cause the groundwater to cascade back into the well, resulting in excessive aeration and potential stripping of volatile constituents.

The actual volume of purged water can be measured using several acceptable methods:

- When bailers are used, the actual volume of each bailer's contents can be measured using a calibrated bucket.
- If a pump is used for purging, the pump rate can be determined by using a bucket of known volume, stopwatch, and the duration of pumping time necessary to purge the known volume.

2.5 SAMPLE COLLECTION

This section first describes general groundwater sample collection procedures. This section also describes procedures for collecting groundwater samples for volatile organic analysis (VOA) and for collecting samples when light or heavy immiscible layers are present in a monitoring well. Samples of light and heavy immiscible layers should be collected before the well is purged.

2.5.1 General Groundwater Sampling Procedures

The technique used to withdraw a groundwater sample from a well should be selected based on the parameters for which the sample will be analyzed. To ensure that the groundwater samples are representative, it is important to avoid physically altering or chemically contaminating the sample during collection, withdrawal, or containerization. If the samples are to be analyzed for volatile organic compounds, it is critical that air does not become entrained in the water column.

Acceptable sampling devices for all parameters are double check valve stainless steel or Teflon bailers, bladder pumps, low-flow positive displacement pumps, or for shallow wells, peristaltic pumps. Additional measurements of field parameters should be performed at the time of sampling.

In some cases, it may become necessary to use dedicated equipment already in the well to collect samples. This is particularly true of high volume, deep wells (>150 feet) where bladder pumps are ineffective and bailing is impractical. If existing equipment must be used, however, determine the make and model of the pump and obtain information on component construction materials from the manufacturer or facility representatives. If an existing pump is to be used for sampling, make sure the flow volume can be reduced so that a reliable VOA sample can be taken. Record the specific port, tap, or valve from which the sample is collected.

General sampling procedures include the following:

- Clean sampling equipment should not be placed directly on the ground. Use a plastic drop cloth or feed line from clean reels. Never place contaminated lines back on reels.

- Check the operation of the bailer check valve assemblies to confirm free operation.

- If the bailer cable is to be decontaminated and reused, it must be made of Teflon-coated stainless steel.

- Lower sampling equipment slowly into the well to avoid degassing the water and damaging the equipment.

- Pump flow rates should be adjusted to eliminate intermittent or pulsed flow. The settings should be determined during the purging operations.

- A separate sample volume should be collected to measure necessary field parameters. Samples should be collected and containerized in the order of the parameters' volatilization sensitivity. Table 3 lists the preferred collection order for common groundwater parameters.

Intermediate containers should never be used to prepare VOA samples and should be avoided for all parameters in general. All VOA containers should be filled at a single sampling point or from a single bailer volume.

2.5.2 Collection of Volatile Organics Samples

This section discusses the collection of samples for VOA using either a bailer or bladder pump in detail. Other pumps (such as positive displacement or peristaltic) can be used. The following factors are critical to the collection of representative samples for VOA: ensuring that no air has become entrained in the water column, low pump flow rates (less than 100 milliliter [mL] per minute, if possible), and avoiding flow surges.

2.5.2.1 Collection with Bailers

Samples for VOA should be collected from the first bailer removed from the well after purging. The most effective means requires two people. One person should retrieve the bailer from the well and pour its contents into the appropriate number of 40-mL VOA vials held by the second person. Cap each vial and invert it. If a bubble exists, unscrew the cap and add more water, or discard and repeat. The sample should be transferred from the bailer to the sample container in a manner that will limit the amount of agitation in order to reduce the loss of volatile organics from the sample.

Always fill VOA vials from a single bailer volume. If the bailer is refilled, samples cannot be considered duplicates or splits.

2.5.2.2 Collection with a Bladder Pump (Well Wizard)

To successfully perform VOA sampling with a Well Wizard bladder pump, the following steps must be completed:

1. Following manufacturer's directions, activate the pump. Full water flow from the discharge tubing will begin after 5 to 15 pumping cycles. These initial pumping cycles are required to purge air from the pump and discharge tubing. The discharge and recharge settings must be manually set and adjusted to pump at optimum flow rates. To activate the bladder, it is best to set the initial cycle at long discharge and recharge rates.

2. Reduce water flow rate for VOA sample collection. To reduce the water flow rate, turn the throttle control valve (located on the left side of the Well Wizard pump control panel) counterclockwise.

3. Collect VOA sample from discharge tubing. VOA vials must be placed beneath the discharge tubing while avoiding direct contact between the vials and the tubing. Never place tubing past the mouth of the VOA vial. The pump throttle control must be turned as necessary to maintain a trickle of water in order to obtain a meniscus in the vial.

4. Continue with non-VOA sampling. Increase pump flow rate by turning the throttle control knob clockwise.

2.5.3 Collection of Light Immiscible Floaters

The approach used when collecting floaters depends on the depth to the floating layer and the thickness of that layer. If the thickness of the floater is 2 feet or greater, a bottom-filling valve bailer should be used. Slowly lower the bailer until contact is made with the floater surface, and lower the bailer to a depth less than that of the floater/water interface depth as determined by preliminary measurements with the interface probe.

When the thickness of the floating layer is less than 2 feet, and the depth to the surface of the floating layer is less than 15 feet, a peristaltic pump can be used to extract a sample.

When the thickness of the floating layer, however, is less than 2 feet and the depth to the surface of the floating layer is beyond the effective "lift" of a peristaltic pump (greater than 25 feet), a bailer can be modified to allow filling from the top only (an acceptable alternative is to use a top- loading Teflon or stainless-steel bailer). Disassemble the bailer's bottom check valve and insert a piece of 2-inch diameter Teflon sheet between the ball and ball seat. This will seal off the bottom valve. Remove the ball from the top check valve, thus allowing the sample to enter from the top. To overcome buoyancy when the bailer is lowered into the floater, place a length of one-inch stainless steel pipe on the retrieval line above the bailer (this pipe may have to be notched to allow sample entry if the pipe remains within the top of the bailer). As an alternative, use a top-loading stainless-steel bailer. Lower the device, carefully measuring the depth to the surface of the floating layer, until the top of the bailer is level with the top of the floating layer. Lower the bailer an additional one-half thickness of the floating layer and collect the sample. This technique is the most effective method of collection if the floating layer is only a few inches thick.

2.5.4 Collection of Heavy Immiscible Sinkers

The best method for collection of sinkers is use of a double check valve bailer. The key to collection is controlled, slow lowering and raising of the bailer to and from the bottom of the well. Collection methods are equivalent to those described in Section 2.5.3 above.

TABLE 1

LIQUID VOLUME IN A 1-FOOT SECTION OF WELL CASING

Well Casing Inside Diameter (D) (inches)	Volume of Liquid in 1-Foot Well Section (gallons) $V= 0.0408\ (D^2)$
1	0.041
1.5	0.092
2	0.163
3	0.367
4	0.653

TABLE 2

FIELD MEASUREMENT TOLERANCE LEVELS

Field Parameter	Tolerance Level
pH	0.1 pH unit
Specific Conductance	10 percent relative percent difference (RPD)[a]
Temperature	1 °C

Note:

[a] RPD can be determined as follows:

$$\text{RPD} = \frac{(\text{Measurement 1} - \text{Measurement 2}) \times 100}{(\text{Measurement 1} + \text{Measurement 2}) / 2}$$

TABLE 3

ORDER OF PREFERRED SAMPLE COLLECTION

1. VOA
2. Purgeable organic halogens (POX)
3. Total organic halogens (TOX)
4. Cyanide
5. Extractable organics
6. Purgeable organic carbon (POC)
7. Total metals
8. Dissolved metals
9. Total organic carbon (TOC)
10. Phenols
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

APPENDIX C

FIELD FORMS

TETRA TECH EM INC.
FIELD INSTRUMENT CALIBRATION LOG

Project No.: ______________________________

Project Name: ______________________________

Instrument Type	Instrument Serial Number	Calibration Type	Date	By

Sheet _____ of _____

TETRA TECH EM INC.

SOIL BORING AND WELL INSTALLATION AND VISUAL CLASSIFICATION LOG

DO:

Bldg./Site:

Project Name:

Boring Number:	Date Started:
Drilling Method: (*Circle one*) HSA Continuous Core/Direct Push/Hand Auger	Date Completed:
Air Rotary/Mud Rotary/Dual Tube Percussion/Sonic/Vacuum	Logged By:
Outer Diameter of Boring:	Drilling Subcontractor:
Inner Diameter of Well Casing:	Driller:
Depth to Water (ft./bgs.)	Location Sketch:

Time	Depth (ft) bgs	Drive Interval	Recovered Interval	Sample ID	Blow count (per 6 inches) / V.B. utility type, dia.	Description	USCS soil symbol	Well construction	OVM (ppm)

TETRA TECH EM INC.

SOIL BORING AND WELL INSTALLATION AND VISUAL CLASSIFICATION LOG

DO:

Bldg./Site:

Project Name:

Time	Depth (ft) bgs	Drive Interval	Recovered Interval	Sample ID	Blow count (per 6 inches) / V.B. utility type, dia.	Description	USCS soil symbol	Well construction	OVM (ppm)

S:\AECRU\Hunters Point Shipyard\DO 0019 (PLOB X027)\WE2-Plans\Draft SAP\for Angela\appendices\Appendix C\04. Soil Boring and Well Installation Log.doc

TETRA TECH EM INC.

MONITORING WELL COMPLETION RECORD

DRILLING INFORMATION

DRILLING BEGAN:

DATE ______ TIME ______

WELL INSTALLATION BEGAN:

DATE ______ TIME ______

WELL COMPLETION FINISHED:

DATE ______ TIME ______

DRILLING CO. ______

DRILLER ______

LICENSE ______

DRILL RIG ______

DRILLING METHOD:

- ☐ HOLLOW STEM AUGER
- ☐ AIR ROTARY
- ☐ ______

DIAMETER OF AUGERS:

ID ______ OD ______

BENTONITE SEAL

AMOUNT CALCULATED ______

AMOUNT USED ______

- ☐ PELLETS, SIZE ______
- ☐ CHIPS, SIZE ______
- ☐ ______

PRODUCT ______

MFG. BY ______

METHOD INSTALLED

☐ POURED ☐ TREMIE

AMOUNT OF WATER USED ______

FILTER PACK

AMOUNT CALCULATED ______

AMOUNT USED ______

- ☐ SAND, SIZE ______
- ☐ FORMATION COLLAPSE:

FROM ______ TO ______

PRODUCT ______

MFG. BY ______

METHOD INSTALLED:

☐ POURED ☐ TREMIE

SURVEY INFORMATION

TOC ELEVATION ______

GROUND ELEVATION ______

NORTHING COORD. ______

EASTING COORD. ______

DATE SURVEYED ______

SURVEY CO. ______

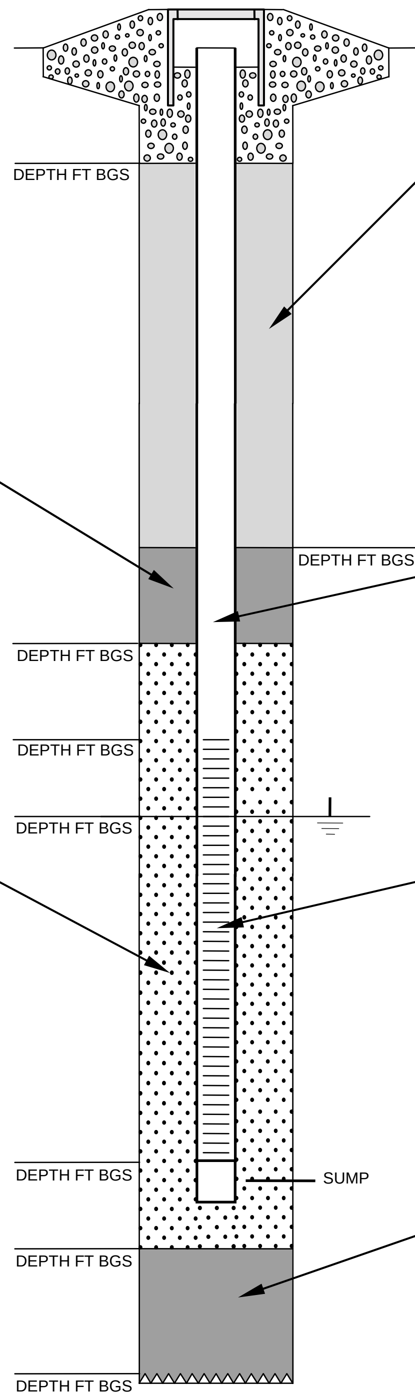
CENTRALIZERS USED?

☐ YES ☐ NO

CENTRALIZER DEPTHS: ______

SURFACE COMPLETION

- ☐ FLUSH MOUNT
- ☐ ABOVE GROUND W/BUMPER POST
- ☐ CONCRETE ☐ ASPHALT



MONITORING WELL

MONITORING WELL NO. ______

PROJECT ______

SITE ______

BOREHOLE NO. ______

WELL PERMIT NO. ______

TOC TO BOTTOM OF WELL ______

ANNULAR SEAL

AMOUNT CALCULATED ______

AMOUNT USED ______

☐ GROUT FORMULA

PORTLAND CEMENT ______

BENTONITE ______

WATER ______

☐ PREPARED MIX

PRODUCT ______

MFG. BY ______

METHOD INSTALLED

☐ POURED ☐ TREMIE

CASING

- ☐ SCHEDULE 40 PVC
- ☐ ______

PRODUCT ______

MFG BY. ______

CASING DIAMETER (in):

ID ______ OD ______

LENGTH OF CASING ______

WELL SCREEN

- ☐ SCHEDULE 40 PVC
- ☐ ______

PRODUCT ______

MFG. BY: ______

CASING DIAMETER (in):

ID ______ OD ______

SLOT SIZE ______

LENGTH OF SCREEN ______

BOREHOLE BACKFILL

AMOUNT CALCULATED ______

AMOUNT USED ______

- ☐ BENTONITE CHIPS, SIZE ______
- ☐ BENTONITE PELLETS, SIZE ______
- ☐ SLURRY ______
- ☐ FORMATION COLLAPSE

FROM ______ TO ______

PRODUCT ______

MFG. BY ______

METHOD INSTALLED:

☐ POURED ☐ TREMIE

TETRA TECH EM INC.
MONITORING WELL SAMPLING SHEET

Date:___________________

Monitoring Well No.:_________________________ Chain of Custody No.:_________________

Personnel:____

Organic Vapor Concentration TOC:_______________ppm Breathing Zone: _______________ppm

Depth to Well Bottom: ____________________ft.

Well Volume: 2-inch well = water column x 0.163 gal/ft
3-inch well = water column x 0.367 gal/ft
4-inch well = water column x 0.652 gal/ft

Depth to Water: ________________________ft.

Water Column:__________________________ft.

Well Volume Calculation:____________________gal

Time	Vol. Purged (____)	Flow Rate (____)	Water Level (____)	pH	Conductivity (____)	Temperature (°C/°F)	Turbidity (NTU)	D. O. (mg/L)	O. R. P. (____)

Begin Purge:__________ Method of Purging________________________________ Purged Dry?__________

End Purge:___________ Total Volume Purged:____________ How Measured?__________________

QA/QC Sample Collected Here? ☐ Duplicate ☐ Matrix Spike ☐ Equip. Blank ☐ No QA/QC Sample

Date and Time of Sample Collection:__________________________Sample Number (s):__________________

Comments:____

____

Tetra Tech EM Inc.

Daily Quality Control Report

Project Name:	**Date:**
Project Number:	**Day:**
Weather:	**Wind:**
Temperature:	**Humidity:**

Personnel on Site

Field Team Leader:

Subcontractors on Site:

Equipment on Site

Work Performed (Including Sampling)

Quality Control Activities

Health and Safety Levels and Activities

Problems Encountered / Corrective Action Taken

Tetra Tech EM Inc.

Daily Quality Control Report

(Page 2 of 2)

Deviations from Field Work Plan

Additional Notes

Anticipated Activities for Tomorrow

Distribution:	**Submitted By:**
	Signature Date

Daily Tailgate Safety Meeting Form

Date: ______________________ Time: ______________________ Job Number: ______________________

Client: ______________________ Site Location: ______________________

Scope of Work: ______________________

Safety Topics Presented

Planned Field Activities for the Day: ______________________

Protective Clothing / Equipment: ______________________

Chemical Hazards: ______________________

Physical Hazards: ______________________

Special Equipment: ______________________

Decontamination Procedures: ______________________

Other: ______________________

Emergency Procedures: ______________________

Hospital: ____________ Phone: ____________ Ambulance Phone: ______________________

Hospital Address and Route: ______________________

Employee Questions / Comments: ______________________

Attendees

Name (Printed)	Signature

Meeting Conducted By:

Name (Printed) / Signature	Name (Printed) / Signature
Site Safety Coordinator	Project Field Manager

Tetra Tech EM Inc.
San Francisco Office

135 Main St. Suite 1800
San Francisco. CA 94105
415-543-4880
Fax 415-543-5480

Chain of Custody Record No. ______

Page ____ of ____

Lab PO#:	Lab:

Project name:	TtEMI technical contact:	Field samplers:
Project (CTO) number:	TtEMI project manager:	Field samplers' signatures:

Sample ID	Sample Location (Pt. ID)	Date	Time	Matrix	MS / MSD	40 ml VOA	1 liter Amber	500 ml Poly	Sleeve	Glass Jar				VOA	SVOA	Pest/PCBs	Metals	TPH Purgeables	TPH Extractables										

(Column groups: No./Container Types — 40 ml VOA through the following blank columns; Analysis Required — VOA through the following blank columns; Preservative Added row above Analysis Required.)

	Name (print)	Company Name	Date	Time
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				

Turnaround time/remarks:

Fed Ex #:

WHITE-Laboratory Copy YELLOW-Sample Tracker PINK-File Copy

Corrective Action Request Form
(Page 1 of 2)

Tetra Tech EM Inc.

Project Name: ______________________ **Date:** ______________________

Project No.: ______________________ **Project Manager:** ______________________

Location: ______________________

To (Project Manager): ______________________

From (Audit Team Members): ______________________

Description of Problem:

____

____

____

____

Corrective Action Required:

____

____

____

____

The above corrective action must be completed by (Date): ______________________

Acknowledgement of Receipt

____

(Signature and Date)

Corrective Action Request Form

Tetra Tech EM Inc.

Corrective Action Taken:

____

____

____

____

Project Manager: ______________________________

(Signature and Date)

Audit Team Members:

Corrective Action *is / is not* satisfactory

____

(Date and Initial)

Remarks: ______________________________

____

____

____

____

QC Coordinators:

Corrective Action *is / is not* satisfactory

____

(Date and Initial)

Remarks: ______________________________

____

____

____

____

cc: Program QA Manager

APPENDIX D

PROJECT-REQUIRED REPORTING LIMITS

(9 Pages)

TABLE D-1

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS (PRRL) AND SCREENING CRITERIA, SVOCS METHOD 8270C, SW-846

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Soil PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5,6] (µg/L)	Freshwater Chronic AWQC[b,5,6] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Acenaphthene	0.016	20[C]	NA	0.33	No[a]	Yes	710	***520***	10	Yes
Acenaphthylene	0.044	NA	NA	0.33	No[a]	NA	***300***	NA	10	Yes
Anthracene	85.3	NA	NA	0.33	Yes	NA	***300***	NA	10	Yes
Benzo(a)anthracene	0.26	NA	NA	0.33	No[a]	NA	***300***	NA	10	Yes
Benzo(a)pyrene	0.43	NA	NA	0.33	Yes	NA	***300***	NA	10	Yes
Benzo(b)fluoranthene	NA	NA	NA	0.33	NA	NA	***300***	NA	10	Yes
Benzo(g,h,i)perylene	NA	NA	NA	0.33	NA	NA	***300***	NA	10	Yes
Benzo(k)fluoranthene	NA	NA	NA	0.33	NA	NA	***300***	NA	10	Yes
Bis(2-chloroethoxy)methane	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
Bis(2-chloroethyl)ether	NA	NA	NA	0.33	NA	NA	NA	122	10	NA
Bis(2-chloroisopropyl)ether	NA	NA	NA	0.33	NA	NA	NA	122	10	NA
Bis(2-ethylhexyl)phthalate	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
4-Bromophenyl-phenylether	NA	NA	NA	0.33	NA	NA	NA	122	10	NA
Butylbenzylphthalate	NA	NA	NA	0.33	NA	NA	***2,944***	3	10	No[a]
Carbazole	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
4-Chloro-3-methylphenol	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
4-Chloroaniline	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
2-Chloronaphthalene	NA	NA	NA	0.33	NA	NA	***7.5***	***1600***	10	No[a]
2-Chlorophenol	NA	NA	NA	0.33	NA	NA	NA	***2000***	10	Yes
4-Chlorophenyl-phenylether	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
Chrysene	0.38	NA	NA	0.33	NA	NA	***300***	NA	10	Yes

TABLE D-1 (Continued)

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS (PRRL) AND SCREENING CRITERIA, SVOCS METHOD 8270C, SW-846
Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Soil PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5,6] (µg/L)	Freshwater Chronic AWQC[b,5,6] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Dibenz(a,h)anthracene	0.063	NA	NA	0.33	No[a]	NA	***300***	NA	10	Yes
Dibenzofuran	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
1,2-Dichlorobenzene	NA	NA	NA	0.33	NA	NA	129	763	10	Yes
1,3-Dichlorobenzene	NA	NA	NA	0.33	NA	NA	129	763	10	Yes
1,4-Dichlorobenzene	NA	20[d]	NA	0.33	NA	Yes	129	763	10	Yes
3,3'-Dichlorobenzidine	NA	NA	NA	1.3	NA	NA	NA	NA	30	NA
2,4-Dichlorophenol	NA	NA	NA	0.33	NA	NA	NA	365	10	NA
Diethylphthalate	NA	100[C]	NA	0.33	NA	Yes	***2944***	3	10	NA
2,4-Dimethylphenol	NA	NA	NA	0.33	NA	NA	NA	***2120***	10	NA
Dimethylphthalate	NA	NA	NA	0.33	NA	NA	***2,944***	3	10	No[a]
Di-n-butylphthalate	NA	200[c]	NA	0.33	NA	Yes	NA	NA	10	NA
4,6-Dinitro-2-Methylphenol	NA	NA	NA	3.3	NA	NA	NA	NA	50	NA
2,4-Dinitrophenol	NA	20[c]	NA	3.3	NA	Yes	***4,850***	***150***	50	Yes
2,4-Dinitrotoluene	NA	NA	NA	0.33	NA	NA	***590***	***230***	10	Yes
2,6-Dinitrotoluene	NA	NA	NA	0.33	NA	NA	***590***	230	10	Yes
Di-n-octylphthalate	NA	NA	NA	0.33	NA	NA	***2,944***	3	10	No[a]
Fluoranthene	0.60	NA	NA	0.33	Yes	NA	16	***3980***	10	Yes
Fluorene	.019	NA	NA	0.33	No[a]	NA	***300***	NA	10	Yes
Hexachlorobenzene	NA	NA	NA	0.33	NA	NA	129	***50***	10	Yes
Hexachlorobutadiene	NA	NA	NA	0.33	NA	NA	***32***	9.3	10	No[a]
Hexachlorocyclopentadiene	NA	10[c]	NA	0.33	NA	Yes	***7.0***	5.2	10	No[a]

TABLE D-1 (Continued)

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS (PRRL) AND SCREENING CRITERIA, SVOCS METHOD 8270C, SW-846
Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Soil PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5,6] (µg/L)	Freshwater Chronic AWQC[b,5,6] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Hexachloroethane	NA	NA	NA	0.33	NA	NA	***940***	540	10	Yes
Indeno(1,2,3-cd)pyrene	NA	NA	NA	0.33	NA	NA	***300***	NA	10	Yes
Isophorone	NA	NA	NA	0.33	NA	NA	**12,900**	***117,000***	10	Yes
2-Methylnaphthalene	.070	NA	NA	0.33	No[a]	NA	NA	NA	10	NA
2-Methylphenol	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
4-Methylphenol	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
Naphthalene	0.16	NA	NA	0.33	No[a]	NA	***2,350***	620	10	Yes
2-Nitroaniline	NA	NA	NA	3.3	NA	NA	NA	NA	50	NA
4-Nitroaniline	NA	NA	NA	1.7	NA	NA	NA	NA	30	NA
3-Nitroaniline	NA	NA	NA	3.3	NA	NA	NA	NA	50	NA
Nitrobenzene	NA	NA	NA	0.33	NA	NA	***6,680***	***27,000***	10	Yes
2-Nitrophenol	NA	NA	NA	0.33	NA	NA	***4,850***	***150***	10	Yes
4-Nitrophenol	NA	7[d]	NA	0.33	NA	Yes	***4,850***	***150***	10	Yes
N-nitroso-di-n-propylamine	NA	NA	NA	0.33	NA	NA	***3,300,000***	***5,850***	10	Yes
N-nitrosodiphenylamine	NA	NA	NA	0.33	NA	NA	***3,300,000***	***5,850***	10	Yes
2,2'-Oxybis(1-chloropropane)	NA	NA	NA	0.33	NA	NA	NA	NA	10	NA
Pentachlorophenol	NA	3[c]	NA	1.7	NA	Yes	7.9	15	50	NA
Phenanthrene	0.24	NA	NA	0.33	No[a]	NA	***300***	NA	10	Yes
Phenol	NA	30[d] 70[c]	NA	0.33	NA	Yes	***5,800***	2560	10	Yes
Pyrene	0.67	NA	NA	0.33	Yes	NA	***300***	NA	10	Yes

TABLE D-1 (Continued)

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS (PRRL) AND SCREENING CRITERIA, SVOCS METHOD 8270C, SW-846
Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Soil PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5,6] (µg/L)	Freshwater Chronic AWQC[b,5,6] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
1,2,4-Trichlorobenzene	NA	20[d]	NA	0.33	NA	Yes	129	***50***	10	NA
2,4,5-Trichlorophenol	NA	4[c] 9[d]	NA	1.7	NA	Yes	NA	NA	50	NA
2,4,6-Trichlorophenol	NA	4[c]	NA	0.33	NA	Yes	NA	970	10	NA

Notes:

a The listed PRRL reflects the maximum sensitivity of current, routinely used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

b Criterion in ***bold italics*** represent acute or other rather than chronic AWQC. For these chemicals, chronic AWQC are not available.

c Plants are the endpoint for this value.

d Earthworms are the endpoint for this value.

1 Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management. 19: 81-97.

2 Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. Technical Memorandum NOS OMA52. National Oceanic and Atmospheric Administration, Seattle, WA.

3 Efroymson, R.A., G.W. Suter, B.E. Sample, and D.S. Jones. 1997a. "Preliminary Remediation Goals for Ecological Endpoints." August.

4 Efroymson, R.A., M.E. Will, G.W. Suter, A.C. Wooten. 1997b. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision." U.S. Department of Energy. November.

5 EPA. 2002. "National Recommended Water Quality Criteria: 2002." EP-822-R-02-047. November.

6 Marshack, J.B. 2000. "A Compilation of Water Quality Goals – August 2000 Edition." RWQCB. August.

AWQC Ambient Water Quality Criteria
ER-L Effects-range low
EPA U.S. Environmental Protection Agency
µg/kg Micrograms per kilograms
µg/L Micrograms per liter
mg/kg Milligrams per kilograms
NA Not available
PRG Preliminary Remediation Goals
PRRL Project-required reporting limit
RWQCB Regional Water Quality Control Board
SVOC Semivolatile organic compound

TABLE D-2

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS AND SCREENING VALUES FOR METALS METHOD 6010B/7000, SW-846

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL [a] (mg/kg)	Sediment PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5,6] (µg/L)	Freshwater Chronic AWQC[b,5,6] (µg/L)	Litigation Area Specific Values[c,7,8] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Aluminum	NA	50[d]	NA	10	NA	Yes	NA	87[e]	87[e]	200	No[a]
Antimony	2	5[d]	NA	3	No[a]	Yes	NA	1600	NA	60	Yes
Arsenic	8.2	9.9[d,f]	9.9[f]	0.25	Yes	Yes	36	150	36	10	Yes
Barium	NA	283[g] 500[d]	283[g]	0.5	Yes	Yes	NA	NA	NA	200	NA
Beryllium	NA	10[d]	NA	0.1	Yes	NA	NA	5.3	NA	5	Yes
Cadmium	1.2	4[d,g]	4.2[g]	0.25	Yes	Yes	8.8	0.22[9]	6.2[h]	5	No[a]
Calcium	NA	NA	NA	25	NA	NA	NA	NA	NA	500	NA
Chromium	81	0.4[i] 1[d]	16.1[g]	0.5	Yes	Yes	50	11	11	10	Yes
Cobalt	NA	20[d]	NA	1.0	Yes	NA	NA	NA	NA	50	NA
Copper	34	60[i] 100[d]	370[f]	0.5	Yes	Yes	3.1	9.0	3.1	3.1	Yes
Iron	NA	NA	NA	5	NA	NA	NA	1000	NA	100	NA
Lead	46.7	40.5[g] 50[d]	40.5[g]	0.15	Yes	Yes	8.1	2.5	8.1	3	No[a]
Magnesium	NA	NA	NA	25	NA	NA	NA	NA	NA	500	NA
Manganese	NA	500[d]	NA	0.5	Yes	NA	NA	NA	NA	15	NA
Mercury	0.15	0.00051[g] 0.3[d]	0.00051[g]	0.02	Yes	Yes	0.94	0.77	0.025[j]	0.1	No[a]

TABLE D-2 (Continued)

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS AND SCREENING VALUES FOR METALS METHOD 6010B/7000, SW-846

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Sediment PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5,6] (µg/L)	Freshwater Chronic AWQC[b,5,6] (µg/L)	Litigation Area Specific Values[c,7,8] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Molybdenum	NA	2[d]	4.75[f]	1.0	Yes	Yes	NA	NA	NA	20	NA
Nickel	20.9	30[d]	121[g]	1.0	Yes	Yes	8.2	52	8.2	8.2	Yes
Potassium	NA	NA	NA	25	NA	NA	NA	NA	NA	500	NA
Selenium	NA	0.21[k] 1[d]	0.21[k]	0.25	No[a]	No[a]	71	5	4.6	5	No[a]
Silver	1	2[d]	NA	0.25	Yes	Yes	***1.9***	***3.2***	1.9[b]	10	No[a]
Sodium	NA	NA	NA	25	NA	NA	NA	NA	NA	500	NA
Thallium	NA	1[d]	2.1[f]	0.25	Yes	Yes	***2130***	40	NA	10	Yes
Vanadium	NA	2[d]	55[f]	0.25	Yes	Yes	NA	NA	NA	50	NA
Zinc	150	8.5[g] 50[d]	8.5[g]	1	Yes	Yes	81.0	120	81	20	Yes

Notes:

a The listed PRRL reflects the maximum sensitivity of current, routinely used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

b Criterion in ***bold italics*** represent acute or other rather than chronic AWQC. For these chemicals, chronic AWQC are not available.

c Lowest total recoverable dissolved concentrations based on either EPA (1998) salt water or fresh water, EPA (1999) salt water or fresh water, or California Toxics Rule (Title 40 Code of Federal Regulations Part 131); these criteria were used during the five year review at the Litigation Area.

d Plants are the endpoint for this value.

e Based on total metals. Criterion valid only for water in the pH range of 6.5 to 9.0. Aluminum may be less toxic at high pH and hardness, but the effects are not well quantified at this time.

f Shrews are the endpoint for this value.

g Woodcocks are the endpoint for this value.

h Criterion is hardness dependent. This value corresponds to a total hardness of 400 mg/L as CaCO3 in the water body.

i Earthworms are the endpoint for this value.

j Bay basin plan criterion for mercury was selected based on the request of the RWQCB.

k Mice are the endpoint for this value.

TABLE D-2 (Continued)

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS AND SCREENING VALUES FOR METALS METHOD 6010B/7000, SW-846

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Notes: (Continued)

1	Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management. 19: 81-97.
2	Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. Technical Memorandum NOS OMA52. National Oceanic and Atmospheric Administration, Seattle, WA.
3	Efroymson, R.A., G.W. Suter, B.E. Sample, and D.S. Jones. 1997b. "Preliminary Remediation Goals for Ecological Endpoints." August.
4	Efroymson, R.A., M.E. Will, G.W. Suter, A.C. Wooten. 1997. "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision." November.
5	EPA. 2002. "National Recommended Water Quality Criteria: 2002." EP-822-R-02-047. November.
6	Marshack, J.B. 2000. "A Compilation of Water Quality Goals – August 2000 Edition." RWQCB. August.
7	EPA. 1998. "Quality Criteria for Water." Office of Water. Washington, DC.
8	EPA. 1999. "National Recommended Water Quality Criteria – Correction." EPA 822-Z-99-001. Office of Water. April.
9	EPA. 2000. "Federal Register: Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule." 40 CFR Part 131. May 18.

AWQC	Ambient Water Quality Criteria
ER-L	Effects-range low
EPA	U.S. Environmental Protection Agency
µg/L	Micrograms per liter
mg/kg	Milligrams per kilograms
NA	Not available
PRG	Preliminary Remediation Goals
PRRL	Project-required reporting limit
RWQCB	California Regional Water Quality Control Board
SVOC	Semivolatile organic compound

TABLE D-3

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS (PRRL) AND SCREENING CRITERIA, PESTICIDES (METHOD 8081A, SW-846) AND PCBS (METHOD 80802, SW-846)

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Sediment PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5] (µg/L)	Freshwater Chronic AWQC[b,5] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Alpha-BHC	NA	NA	NA	0.003	NA	NA	NA	NA	0.05	NA
Gamma-BHC (Lindane)	NA	NA	NA	0.003	NA	NA	***0.16***	***0.95***	0.05	Yes
Heptachlor	NA	NA	NA	0.003	NA	NA	NA	NA	0.05	NA
Aldrin	NA	NA	NA	0.003	NA	NA	***1.3***	***3.0***	0.05	Yes
Chlordane	0.005	NA	NA	0.003	Yes	NA	0.004	0.0043	0.05	No[a]
4,4'-DDD	NA	NA	NA	0.006	NA	NA	NA	NA	0.1	NA
4,4'-DDE	0.022	NA	NA	0.006	Yes	NA	NA	NA	0.1	NA
4,4'-DDT	NA	NA	NA	0.006	NA	NA	0.001	0.001	0.1	No[a]
Total DDT	0.0016	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	0.0002	NA	NA	0.006	No[a]	NA	0.0019	0.056	0.1	No[a]
Endrin	0.0002	NA	NA	0.006	No[a]	NA	0.0023	0.036	0.1	No[a]
Heptachlor	NA	NA	NA	0.006	NA	NA	0.0036	0.0038	0.1	No[a]
Heptachlor epoxide	NA	NA	NA	0.006	NA	NA	0.0036	0.0038	0.1	No[a]
Methoxychlor	NA	NA	NA	0.017	NA	NA	0.03	0.03	0.5	No[a]
Toxaphene	NA	NA	NA	0.17	NA	NA	NA	NA	5.0	NA
Aroclor 1016	0.023[c]	0.371[c,d]	0.371[c,d]	0.033	No[a]	Yes	0.03[e]	0.014[e]	1.0	No[a]
Aroclor 1221	0.023[c]	0.371[c,d]	0.371[c,d]	0.067	No[a]	Yes	0.03[e]	0.014[e]	2.0	No[a]

TABLE D-3 (Continued)

COMPARISON OF PROJECT-REQUIRED REPORTING LIMITS (PRRL) AND SCREENING CRITERIA, PESTICIDES (METHOD 8081, SW-846) AND PCBS (METHOD 80802, SW-846)

Data Gaps Evaluation for the Litigation Area

Naval Weapons Station Seal Beach Detachment, Concord

Analyte	Sediment ER-L[1,2] (mg/kg)	Soil PRG[3,4] (mg/kg)	Final Soil PRG for Wildlife[3] (mg/kg)	Soil PRRL[a] (mg/kg)	Sediment PRRL Below ER-L?	Soil PRRL Below PRG?	Marine Chronic AWQC[b,5] (µg/L)	Freshwater Chronic AWQC[b,5] (µg/L)	Water PRRL[a] (µg/L)	Water PRRL Below Most Conservative AWQC ?
Aroclor 1232	0.023[c]	0.371[c,d]	0.371[c,d]	0.033	No[a]	Yes	0.03[e]	0.014[e]	1.0	No[a]
Aroclor 1242	0.023[c]	0.371[c,d]	0.371[c,d]	0.033	No[a]	Yes	0.03[e]	0.014[e]	1.0	No[a]
Aroclor 1248	0.023[c]	0.371[c,d]	0.371[c,d]	0.033	No[a]	Yes	0.03[e]	0.014[e]	1.0	No[a]
Aroclor 1254	0.023[c]	0.371[c,d]	0.371[c,d]	0.033	No[a]	Yes	0.03[e]	0.014[e]	1.0	No[a]
Aroclor 1260	0.023[c]	0.371[c,d]	0.371[c,d]	0.033	No[a]	Yes	0.03[e]	0.014[e]	1.0	No[a]

Notes

a The listed PRRL reflects the maximum sensitivity of current, routinely used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

b Criterion in ***bold italics*** represent acute rather than chronic AWQC. For these chemicals, chronic AWQC are not available.

c Shrews are the endpoint for this value.

d The PCB value was used.

1 Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management. 19: 81-97.

2 Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. Technical Memorandum NOS OMA52. National Oceanic and Atmospheric Administration, Seattle, WA.

3 Efroymson, R.A., G.W. Suter, B.E. Sample, and D.S. Jones. 1997b. “Preliminary Remediation Goals for Ecological Endpoints.” August.

4 Efroymson, R.A., M.E. Will, G.W. Suter, A.C. Wooten. 1997. “Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.” November.

5 EPA. 2002. “National Recommended Water Quality Criteria: 2002.” EP-822-R-02-047. November.

AWQC Ambient Water Quality Criteria
ER-L Effects-range low
EPA U.S. Environmental Protection Agency
µg/kg Micrograms per kilograms
µg/L Micrograms per liter
mg/kg Milligrams per kilograms
NA Not available
PCB Polychorinated biphenyl
PRG Preliminary Remediation Goals
PRRL Project-required reporting limit
SVOC Semivolatile organic compound

APPENDIX E

APPROVED NAVY LABORATORIES

(1 Page)

TABLE E-1

TETRA TECH EM INC.-APPROVED NAVY LABORATORIES UNDER BASIC ORDERING AGREEMENT

Data Gaps Evaluation for the Litigation Area
Naval Weapons Station Seal Beach Detachment, Concord

Analytical Group	
Lab Address:	12189 Pennsylvania Street Thornton, CO 80241
Point of Contact:	Joe Egry / Mary Fealey
Phone:	(800) 873-8707 X103/X135
Fax:	(303) 469-5254
Business Size:	SWO
E-mail	mfealey@analyticagroup.com

Applied Physics and Chemistry Laboratory	
Lab Address:	13760 Magnolia Avenue Chino, CA 91710
Point of Contact:	Dan Dischner / Eric Wendland
Phone:	(909) 590-1828 X203/X104
Fax:	(909) 590-1498
Business Size:	SDB
E-mail	marketing@apclab.com

Columbia Analytical Services	
Lab Address:	5090 Caterpillar Road Redding, CA 96003
Point of Contact:	Karen Sellers / Howard Boorse
Phone:	(530) 244-5262 / (360) 577-7222
Fax:	(530) 244-4109
Business Size:	LB
E-mail	lkennedy@kelso.caslab.com

Curtis and Tompkins, Ltd	
Lab Address:	2323 Fifth Street Berkeley, CA 94710
Point of Contact:	Anna Pajarillo / Mike Pearl
Phone:	(510) 486-0925 X103/ X108
Fax:	(510) 486-0532
Business Size:	SB
E-mail	mikep@ctberk.com

EMAX Laboratories Inc.	
Lab Address:	1835 205th Street Torrance, CA 90501
Point of Contact:	Ye Myint / Jim Carter
Phone:	(310) 618-8889 X121/X105
Fax:	(310) 618-0818
Business Size:	SDB/WO
E-mail	ymyint@emaxlabs.com

Laucks Laboratories	
Lab Address:	940 S. Harney Street Seattle, WA 98108
Point of Contact:	Mike Owens / Kathy Kreps
Phone:	(206) 767-5060
Fax:	(206) 767-5063
Business Size:	SB
E-mail	KathyK@laucksIabs.com

Sequoia Analytical	
Lab Address:	1455 McDowell Blvd. North, Suite D
	Petaluma, CA 94954
Point of Contact:	Angelee Cari
Phone:	(707) 792-7527
Fax:	(707) 792-0342
Business Size:	LB
E-mail	acari@sequoialabs.com

Notes:

DHS	California Department of Health Services
LB	Large business
SB	Small business
SDB	Small disabled business
SWO	Small woman-owned
WO	Woman-owned